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Improving Network Lifetime and Reducing Energy Consumption in Wireless Sensor Networks

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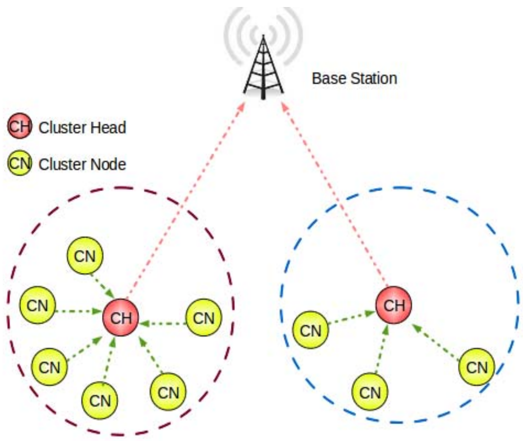
Abstract-Energy efficiency and sensing coverage are essential metrics for enhancing the lifetime and the utilization of wireless sensor networks. Many protocols have been developed to address these issues, among which, clustering is considered a key technique in minimizing the consumed energy. However, few clustering protocols address the sensing coverage metric. An efficient power saving scheme and corresponding algorithm must be developed and designed in order to provide reasonable energy consumption and to improve the network lifetime for wireless sensor network systems. The cluster-based technique is one of the approaches to reduce energy consumption in wireless sensor networks. In this article, we propose a clustering algorithm to provide efficient energy consumption in such networks. The main idea of this article is to reduce data transmission distance of sensor nodes in wireless sensor networks by using the uniform cluster concepts. In order to make an ideal distribution for sensor node clusters, we calculate the average distance between the sensor nodes and take into account the residual energy for selecting the appropriate cluster head nodes. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network loading among the clusters. Simulation results indicate the superior performance of our proposed algorithm to strike the appropriate performance in the energy consumption and network lifetime for the wireless sensor networks.

Keywords: **WSN, Clustering, Energy Efficiency,Life Time, Sensing Coverage.**

INTRODUCTION

Recently, there has been a rapid growth in the wireless communication technique. Inexpensive and low-power wireless micro-sensors are designed and widely used in wireless and mobile environments. A wireless sensor network consists of a large number of sensor nodes. Each sensor node has sensing, computing, and wireless communication capability. All sensor nodes play the role of an event detector and the data router. Sensor nodes are deployed in the sensing area to monitor specific targets and collect data. Then, the sensor nodes send the data to sink or base station (BS) by using the wireless transmission technique. Wireless sensor networks have been pervasive in various applications including health care system, battlefield surveillance system, environment monitoring system, and so on. Power saving is one of the most important features for the sensor nodes to extend their lifetime in wireless sensor networks. A sensor node consumes mostly its energy in transmitting and receiving packets. In wireless sensor networks, the main power supply of the sensor nod is battery. However, in most application scenarios, users are usually difficult to reach the location of sensor nodes. Due to a large number of sensor nodes, the replacement of batteries might be impossible. However, the battery energy is finite in a sensor node and a sensor node draining of its battery may make sensing area uncovered. Hence, the energy conservation becomes a critical concern in wireless sensor networks. In order to increase energy efficiency and extend the network lifetime, new and efficient power saving algorithms must be developed. Low Energy Adaptive Clustering Hierarchy (LEACH) is a typical cluster-based protocol using a distributed clustering formation algorithm. In LEACH, the large number of sensor nodes will be divided into several clusters. For each cluster, a sensor node is selected as a cluster head. The selection of cluster head nodes is based on a predetermined probability. Other non-cluster head nodes choose the nearest cluster to join by receiving the strength of the advertisement message from the cluster head nodes. A non-cluster head node can only monitor the environment and send data to its cluster head node. The cluster head node is responsible for collecting the information of non-cluster head nodes in the cluster. Then, it processes data and sends data to the BS. As a non-cluster head node cannot send data directly to the BS, the data transmission distance of the sensor node is shrunk. Therefore, the energy consumption is reduced in the wireless sensor networks. However, the random selection of the cluster head node may obtain a poor clustering setup, and cluster head nodes may be redundant for some rounds of operation. The distribution of cluster head nodes is not uniform, thus some sensor nodes have to transfer data through a longer distance and the reasonable energy saving is not obtained in wireless sensor networks. LEACH-centralized (LEACH-C) is proposed as an improvement of LEACH which uses a centralized clustering algorithm to create the clusters. In LEACH-C, the BS collects the information of the position and energy level from all sensor nodes in the networks. Based on this information, the BS calculates the number of cluster head nodes and configures the network into clusters. In order to make an ideal distribution for sensor node clusters, we calculate the average distance between the sensor nodes and take into account the residual energy for selecting the appropriate cluster head nodes. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network loading among the clusters. The main benefits of proposed scheme are that the energy consumption is reduced and better network lifetime can be carried out.



Cluster based Wireless Sensor Networks

I. SYSTEM MODEL

The system infrastructure is composed of a BS and some sensor nodes. We classify all sensor nodes into non-cluster head nodes and cluster head nodes. The non-cluster head nodes operate in sensing mode to monitor the environment information and transmit data to the cluster head node. Also, the sensor node becomes a cluster head to gather data, compresses it and forwards to the BS in cluster head mode.

Radio energy dissipation model

In wireless sensor networks, data communications consume a large amount of energy. The total energy consumption consists of the average energy dissipated by data transmission of the non-cluster head nodes and the cluster head nodes. In addition, the energy consumption for data collection and aggregation of cluster head nodes is considered. In the radio energy dissipation model in wireless sensor networks, to exchange an L-bit message between the two sensor nodes, the energy consumption can be calculated by.

$$ETx(L, d) = Eelec \times L + \varepsilon amp \times L,$$
$$ERx(L) = Eelec \times L,$$

where ‘d’ is the distance between the two sensor nodes,
‘ETx(L,d)’ is the transmitter energy consumption,
‘ERx(L)’ is the receiver energy consumption.
‘Eelec’ is the electronics energy consumption per bit in the transmitter and receiver sensor nodes.
‘εamp’ is the amplifier energy consumption in transmitter sensor nodes, which can be calculated by

$$\varepsilon amp = \begin{cases} \varepsilon fs \;\square\; d2, \text{ when } d \leq d0 \\ \varepsilon mp \;\square\; d4, \text{ when } d > d0 \end{cases}$$

where d0 is a threshold value. If the distance d is less than d0, the free-space propagation model is used. Otherwise, the multipath fading channel model is used. εfs and εmp are communication energy parameters. Using the previously described in the literature , the εfs is set as 10 pJ/bit/m2 and εmp is set as 0.0013 pJ/bit/m4. Also, the energy for data aggregation of a cluster head node is set as EDA = 5 nJ/bit/signal and the initial energy of a sensor node is set as Einit = 2 J. Suppose that a non-cluster head node N transmits LN bits to the BS. Let dN, CH be the distance between the non-cluster head node N and its cluster head node CH. Let dCH, BS be the distance between the cluster head node CH and the BS. Due to the multi-hop communication, a noncluster head node only sends data to its cluster head node. The residual energy of the non-cluster head node N is equal to Einit - ETx(LN, dN, CH). In addition, the residual energy of the cluster head node CH is equal to Einit - ERx(LN) - EDA - ETx(LN, dCH, BS), because the cluster head node must collect and process the information of non-cluster head nodes in the cluster, and then send data to the BS. It is obvious that the data transmission between sensor nodes takes most of the energy consumption in the wireless sensor networks. Taking into account the energy consumption of sensor nodes, the data transmission distance must be reduced and the packets delay should be avoided. Hence, the energy consumption and routing design become an important issue in the wireless sensor networks.

II. PROPOSED MODEL

In order to increase energy efficiency and extend the lifetime of the sensor nodes in wireless sensor networks, efficient power saving algorithm must be developed and designed. Based on the centralized clustering architecture, here proposed a clustering algorithm to provide efficient energy consumption and better network lifetime in the wireless sensor networks named CAFEE (Clustering Algorithm for Energy Efficient). In the proposed scheme, assume that the BS receives the information of location and residual energy for each sensor node and the average residual energy can be calculated. Fig:1 shows the energy consumption of the nodes of the proposed algorithm. When the residual energy of sensor node is higher than the average residual cluster head. The modify k-means algorithm to make an ideal distribution for sensor node clusters by using the information of location and residual energy for all sensor nodes. Fig:2 shows the transmission latency of the nodes. In this algorithm, the operation includes two models: set up model and Steady sate model.

Set up Model

The main goal of this phase is to create clusters and find cluster head nodes. During the set-up phase, the BS collects the information of the position and energy level from all sensor nodes in the networks. Based on the characteristics of stationary sensor nodes, the suitable initial means of points for clusters can be obtained. However, the cluster head nodes are selected by creating some clusters in our proposed algorithm. The setting of initial means of points is very important. It can reduce the iteration time for creating clusters significantly. After the initial means of points are set, based on the location of all sensor nodes, the BS creates some clusters. We use the k-means algorithm to partition the n sensor nodes into k clusters in which each sensor node belongs to the cluster with the nearest mean of point. In order to create uniform distributed clusters, the minimal distance between the means of points and all sensor nodes is calculated. Then, the sensor nodes are classified into the cluster according to the minimal distance.

III. SIMULATION MODEL

Steady State Model

Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. The non-cluster head nodes send data to cluster head node during their allocated transmission time. When all the data have been received, the cluster head node performs signal processing to compress the data into a single signal. Then, this signal is sent to the BS. The amount of information is reduced due to the data aggregation done at the cluster head node. This round is done and the next round begins with set-up and steady-state phases repeatedly. To avoid unnecessary nodes control messages transmission and control overhead of the BS, the clusters are re-created only when the sensor node cannot work in a certain round. So, the calculating overhead is only cluster head selecting in the most set-up phase.

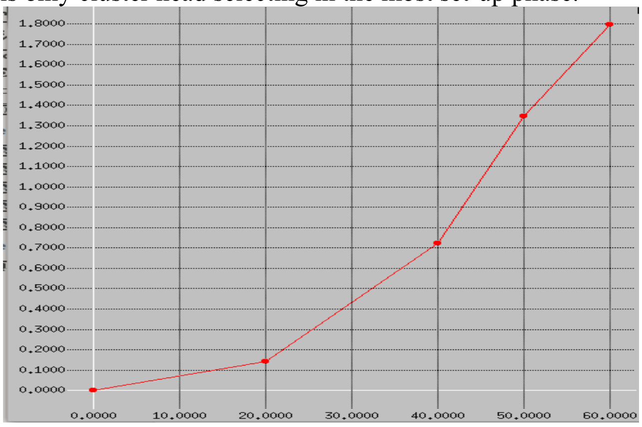


Fig:1 Energy consumption

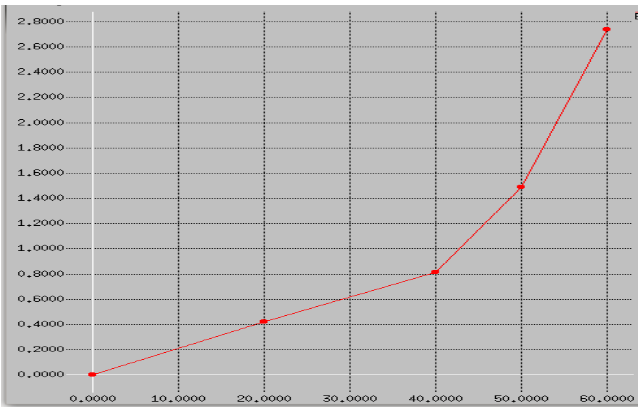


Fig:2 Transmission Latency

IV. CONCLUSION

The energy saving is a challenging issue in the wireless sensor networks. To increase Energy efficient and extend the lifetime of sensor node, new and efficient energy saving schemes must be developed. In the proposed scheme, we calculate the average distance between the sensor nodes and take into account the residual energy for selecting the appropriate cluster head nodes. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network loading among the clusters. Simulation results indicate our proposed algorithm achieves the low energy consumption and better network lifetime in the wireless sensor networks.

SIMULATOR	Network Simulator 2
NUMBER OF NODES	Random
TOPOLOGY	Random
INTERFACE TYPE	Phy/WirelessPhy
MAC TYPE	802.11
QUEUE TYPE	Drop tail/Priority Queue
QUEUE LENGTH	200 Packets
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	Two ray Ground
ROUTING PROTOCOL	AODV
TRANSPORT AGENT	UDP
APPLICATION AGENT	CBR
TRANSMISSION POWER	3.0
RECEPTION POWER	1.0
IDLE POWER	0.0watts
INITIAL ENERGY	Random
SIMULATION TIME	150seconds

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