Energy Conservation in WSN for Application without Prior Knowledge of Cluster Numbers

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Abstract—— The large-scale deployment of wireless sensor networks (WSNs) and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime. The nodes in sensor networks have limited battery power and it is not feasible to recharge or replace the batteries, therefore power consumption should be minimized so that overall network lifetime will be increased. In this paper, we review the few clustering protocol &we present the clustering method which improve energy-efficiency & is useful in those application where the number of clusters is not known a priori, or distribution of nodes is random. For this purpose we use genetic algorithm (GA) to evolve the population of nodes over generations to find those node which can survive in next population. For clustering we use k-means algorithm which effectively selects the cluster head (CH).Therefore, this clustering scheme does not need to pre-specify the number of clusters as in existing methods.

Keywords-*WSN, GA, CH,clustering.*

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I. INTRODUCTION

Wireless sensor network (WSNs) are applied to various fields of science and technology. WSNs have large number of applications such as Process Management, Health care monitoring, Natural disaster prevention, Industrial monitoring, Data logging etc. A WSN is composed of hundreds or even thousands of tiny, cheap sensors nodes which communicate with one another wirelessly and one or more sink nodes. A typical node of a WSN consist of five components: A sensor that performs the sensing of required events in a specific field, transceiver that performs radio transmission and reception, a controller which is used for data processing, Power source i.e. battery which is a power unit providing energy for operation and memory to store events, data etc. Figure 2 gives an overview of sensor node.

Wireless sensor nodes typically do not have very much computational power, limiting the kinds of networking protocols and security techniques they can use. Furthermore batteries have a short lifetime and cannot be replaced on sensor nodes because WSNs are composed of so many nodes, replacing batteries is not feasible. Therefore, there is a need to minimize energy consumption in WSNs. The following steps can be taken to save energy caused by communication in wireless sensor networks [1].

a) To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep).
b) Changing the transmission range between the sensing nodes.
c) Using efficient routing and data collecting methods.
d) Avoiding the handling of unwanted data as in the case of overhearing.

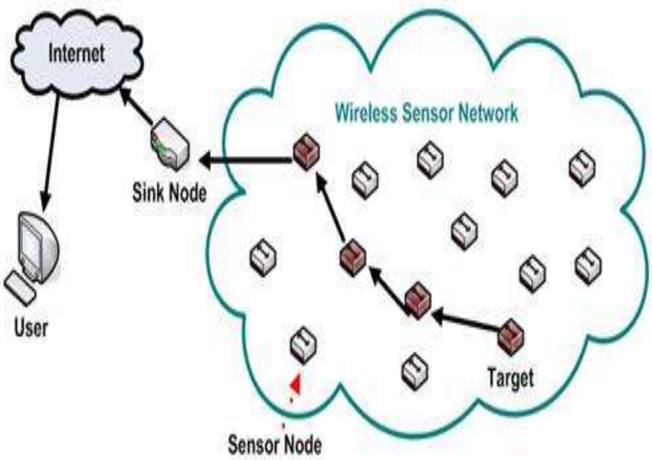

Figure 1. Wireless sensor network

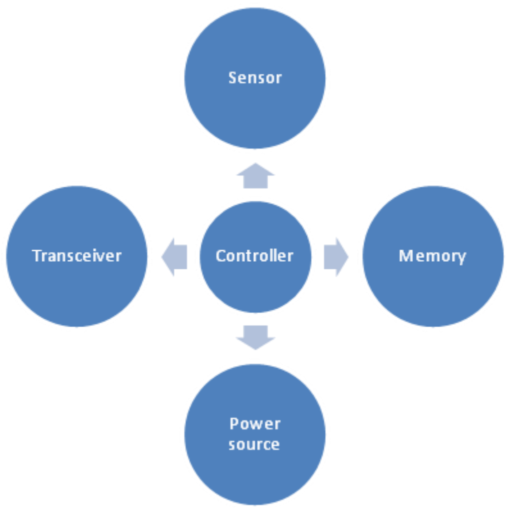

Figure 2. Overview of sensor node

II. DATA CLUSTERING

Clustering groups data instances into subsets in such a manner that similar instances are grouped together, while different instances belong to different groups. A loose definition of clustering could be "the process of organizing objects into groups whose members are similar in some way". A cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters.

We can show this with a simple graphical example:

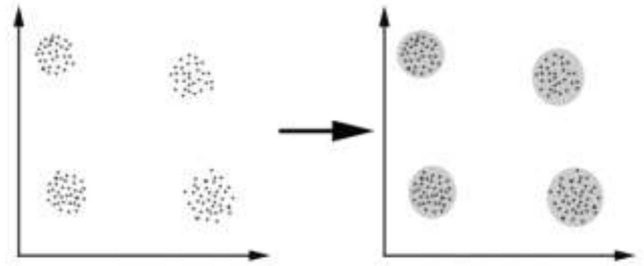

Figure 3. Clustering example

In this case we easily identify the 4 clusters into which the data can be divided; the similarity criterion is distance: two or more objects belong to the same cluster if they are "close" according to a given distance (in this case geometrical distance). This is called distance-based clustering.

In each cluster, sensor nodes are given different roles to play, such as cluster head (CH), ordinary member node (MN), or gate way node. Sensor nodes, referred as source nodes, can gather information from the monitoring region and send the sensing information to their corresponding cluster head [2]. The cluster head (CH) is elected from all the sensor nodes in a cluster according to some criteria, and is responsible for collecting sensing data from source nods. After receiving data from source nodes, the cluster head also performs data aggregation to reduce the data size before sending data to the sink, which further reduces the power expended for data transfer [3]. Clustering is a good method in wireless sensor networks (WSNs) for effective data communication and towards energy efficiency [4].

A. *Advantages of clustering*

- reduction in energy consumption
- WSN lifetime prolonged
- Data aggregation & reducing volume of transmitted data
- WSN scalability
- Communication overhead reduction
- Data overhead reduction
- Delay reduction
- Load balanced distribution
- Bandwidth efficiency
- Stability of network topology
- reducing the size of the routing table in member node

B. *Clustering Technique*

With clustering in WSNs, energy consumption, lifetime of the network and scalability can be improved. Various routing techniques are as follows:

a) Low-Energy Adaptive Clustering Hierarchy (LEACH): **Is** one of the pioneering clustering routing approaches for WSNs [5]. The basic idea of LEACH has been an inspiration for many subsequent clustering routing protocols. The operation of LEACH is broken up into lots of *rounds*, where each round is separated into two phases,

i. Set-up phase : In the set-up phase the clusters are organized
ii. Steady-state phase: In the steady-state phase data is delivered to the BS.

During the set-up phase, each node decides whether or not to become a CH for the current round. Cluster-heads can be chosen stochastically (randomly based) on this algorithm:

$$T(n) = \frac{P}{1 - P \times (r \bmod \frac{1}{P})} \qquad n \in G$$

$$= 0 \qquad \text{otherwise}$$

Where P is cluster head probability,
n is a random number between 0 and 1
r is the current round,
G is the set of nodes that have not been elected CHs in the last 1/*P* rounds.

During the steady-state phase, the sensor nodes sense and transmit data to the CHs. The CHs compress data arriving from nodes that belong to the respective cluster, and send an aggregated or fused packet to the BS directly. Besides, LEACH uses a TDMA/code-division multiple access (CDMA) MAC to reduce inter-cluster and intra-cluster collisions.

LEACH is a completely distributed approach and requires no global information of network.

The advantages of LEACH include the following:

(1) Any node that served as a CH in certain round cannot be selected as the CH again, so each node can equally share the load imposed upon CHs to some extent
(2) Utilizing a TDMA schedule prevents CHs from unnecessary collisions
(3) Cluster members can open or close communication interfaces in compliance with their allocated time slots to avoid excessive energy dissipation.

However, there exist a few disadvantages in LEACH as follows:

(1) It performs the single-hop inter-cluster, directly from CHs to the BS, routing method, which is not applicable to large-region networks.
(2) LEACH cannot ensure real load balancing in the case of sensor nodes with different amounts of initial energy, because CHs are elected in terms of probabilities without energy considerations.
(3) Since CH election is performed in terms of probabilities, it is hard for the predetermined CHs to be uniformly distributed throughout the network.
(4) LEACH needs re-clustering in each round, which may diminish any energy savings gain.

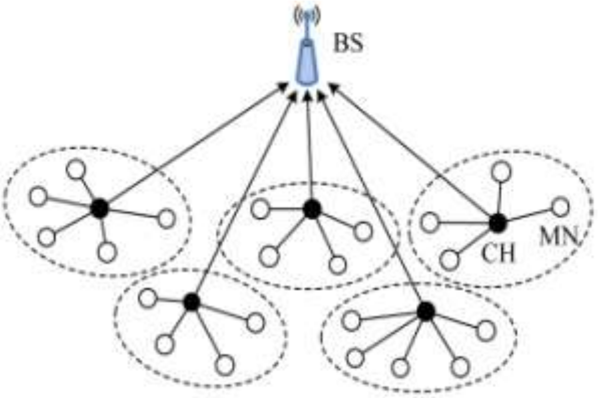

Figure 4. The Basic Topology of LEACH

b) Hybrid Energy-Efficient Distributed Clustering (HEED):

[6] is a multi-hop WSN clustering algorithm which brings an energy-efficient clustering routing with explicit consideration of energy. Different from LEACH in the manner of CH election, HEED does not to select nodes as CHs randomly. The manner of cluster construction is performed based on the hybrid combination of two parameters. One parameter depends on the node's residual energy, and the other parameter is the intra-cluster communication cost. In HEED, elected CHs have relatively high average residual energy compared to MNs. Additionally; one of the main goals of HEED is to get even-distributed CHs throughout the networks. Moreover, despite the phenomena that two nodes, within each other's communication range, become CHs together, but the probability of this phenomena is very small in HEED.

The advantages of the HEED protocol are as follows:

(1) It is a fully distributed clustering method that benefits from the use of the two important parameters for CH election

(2) It provides uniform CH distribution across the network and load balancing.

(3) Communications in a multi-hop fashion between CHs and the BS promote more energy conservation and scalability in contrast with the single-hop fashion, i.e., long-range communications directly from CHs to the sink, in the LEACH protocol [7].

However, there are some limitations with HEED as follows:

(1) The use of tentative CHs that do not become final CHs leave some uncovered nodes.

(2) Similar to LEACH, the performing of clustering in each round imposes significant overhead in the network. This overhead causes noticeable energy dissipation which results in decreasing the network lifetime

(3) HEED suffers from a consequent overhead since it needs several iterations to form clusters. At each iteration, a lot of packets are broadcast.

(4) Some CHs, especially near the sink, may die earlier because these CHs have more work load, and the hot spot will come into being in the network [8, 9].

C) Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN):

[10] Is a hierarchical protocol whose main goal is to cope with sudden changes in the sensed attributes such as temperature. The protocol combines the hierarchical technique in line with a data-centric approach. The nodes sense their environment continuously, but the energy consumption in this algorithm can potentially be much less than that in the proactive network, because data transmission is done less frequently.

In TEEN, a 2-tier clustering topology is built as illustrated in Figure 5 and two thresholds, hard threshold and soft threshold, are defined. The former threshold is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its CH. The latter threshold is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.

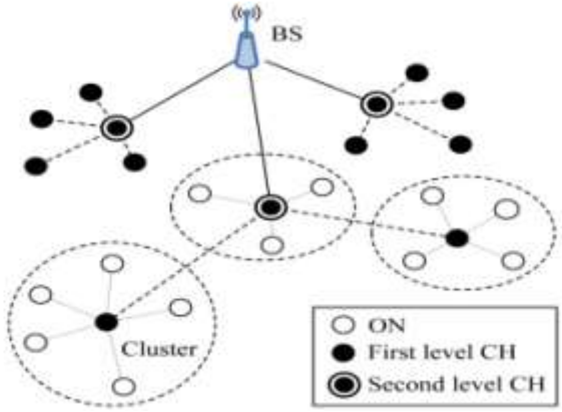

Figure. 5.
Example of the 2-tier Clustering Topology in TEEN.

TEEN has the following advantages:

(1) Based on the two thresholds, data transmission can be controlled commendably, i.e., only the sensitive data we demand can be transmitted, so that it reduces the energy transmission consumption and improves the effectiveness and usefulness of the receiving data

(2) TEEN is complement for reacting to large changes in the sensed attributes, which is suitable for reactive scenes and time critical applications.

However, there exist a few drawbacks in TEEN as follows:

(1) It is not suitable for periodic reports applications since the user may not get any data at all if the values of the attributes may not reach the threshold [11]

(2) There exist wasted time-slots and a possibility that the BS may not be able to distinguish dead nodes from alive ones, because only when the data arrive at the hard threshold and has a variant higher than the soft threshold did the sensors report the data to the BS

(3) If CHs are not in the communication range of each other the data may be lost, because information propagation is accomplished only by CHs [12].

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III. PROPOSED CLUSTERING METHOD

The paper do not claim that this is completely new devised method but its significance in certain application has not been taken into account previously, so its use in application where prior knowledge of number of cluster is not specified in advance has given a major importance. Propose method use genetic algorithm for node deployment and to evolve the population of nodes over generations to find those node which can survive in next population. For clustering we use k-means algorithm which effectively selects the cluster head (CH).

The genetic operators used in GA are the selection, the distance based mutation and the K-means operator.

1) Selection: The selection operator involves random selection of a chromosome from the previous population according to the distribution given by

$$P\ (s_i) = \frac{F(Si)}{\sum_{j=1}^{N} F(Sj)}$$

F (s_i) represents fitness value of the string s_i in the population. Solutions in the current population are estimated based on their merit to survive in the next population. This requires that each solution in a population be associated with a fitness value. The fitness value of a solution string depends on the total within cluster variation. A solution string that has relatively small square error must have relatively high fitness value.

2) Mutation: Mutation changes the value of solutions based on the distance between the cluster centroids and the corresponding data points. Each solution corresponds to a data point whose value represents the cluster to which that data point belongs. The probability of changing value of a cluster number is more if the corresponding cluster center is closer to data point.

3) K-Means Operator: The following three steps constitute k-means operator:

Step 1: Determine the Cluster Head or centroid

Step 2: Determine the distance of each node to the Cluster Head

Step 3: Re- Cluster the nodes based on minimum distance (find the closest Cluster Head).

Figure 6 Shows flowchart of k-means operator in GA

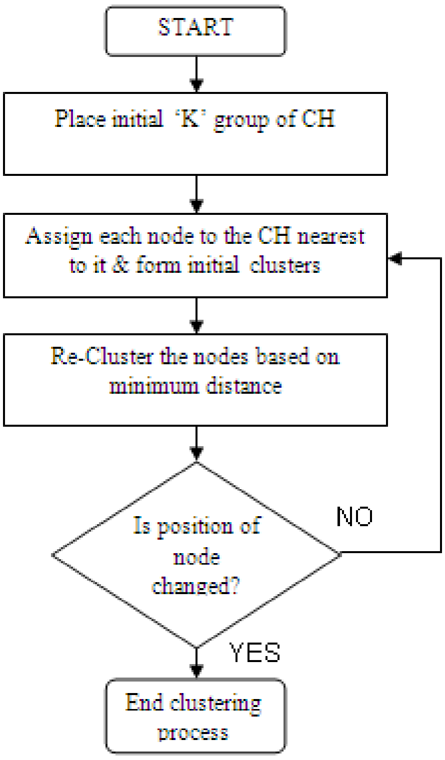

Figure 6. Flow chart of K- means operator in GA

IV. EXPERIMENTAL RESULT

In our work we carry out the simulation with 50 sensors nodes deployed randomly using GA shown in Figure 7, then using K-means algorithm Clusters are form and cluster heads are selected and with evolution in GA the nodes are re-assigned to nearest possible CH based on shortest distance, which helps in finding the shortest path for packet data transfer from MN to CH and then to Base station

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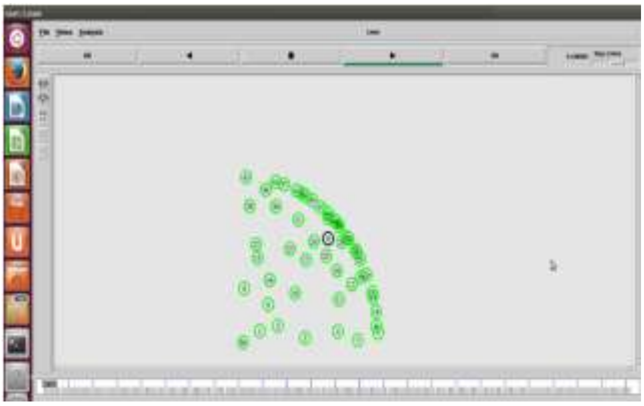

Figure 7. Initial node distribution

Figure 8.Clustering & CH selection

Figure 9. Clustered Network

V. CONCLUSION

Brief introduction about WSNs, routing techniques, clustering is presented. There are so many routing techniques developed to solve the energy consumption problem and for enhancing the lifetime of WSNs. But mostly every technique has certain limitations. In Proposed clustering method the GA is used for random node deployment & to evolve the population of nodes over generations to find those nodes which can survive in next population & clustering is done by k-means algorithm which effectively selects the cluster head and with evolution re-clusters the nodes to nearest possible CH. Therefore, this clustering scheme does not need to pre-specify the number of clusters as in existing methods and hence useful in those areas where number of clusters is not specified beforehand. Hence with clustering it saves networks energy & prolongs network life time. GA helps in quickly finding the shortest possible path for data packet transfer across WSN from MN to CHs and then to Base station (Sink node) which further enhances network energy.

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