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A Mobile Agent-based Clustering Data Fusion Algorithm in WSN

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Abstract—In wireless sensor networks,the mobile agent technology is used in data fusion. According to the node residual energy and the results of partial integration,we design the node clustering algorithm. Optimization of mobile agent in the routing within the cluster strategy for wireless sensor networks to further reduce the amount of data transfer. Through the experiments, using mobile agents in the integration process within the cluster can be reduced the path loss in some extent.

Keywords—wireless sensor networks; data fusion; mobile agent

I. INTRODUCTION

WIRELESS sensor network (WSN) is made of a large number of sensor nodes in the way of self-organization and multi-hop [1][2]. In the WSN, the communication cost is several orders of magnitude higher than the computational cost [3]. So, we improve agent technology and data aggregation for the data collection process in order to minimize the times of data transmission [4][5].

In battery energy, computing ability and storage capacity, the sensor nodes are limited, so how to use the limited energy of sensor nodes in network design effectively is the important issue. Because the detection range and reliability of each node are limited, in order to enhance the accuracy and robustness of the network, we must make the monitoring range overlap each other. So there is certain redundancy in the data of the sensor nodes. In the routing that each node transmits its detection data to the sink node, it is necessary for data fusion in order to reduce redundant information, save energy and prolong the network lifetime. This paper, we research the data fusion in the network layer.

In network layer, the fusion algorithm is mainly based on clustering.The typical clustering algorithm is LEACH[6].It chooses head nodes through cycle way randomly, and balances all the energy of the network to each sensor node. Then the head nodes achieve date integration. In this way, it can reach the purpose of reducing energy consumption. Although the LEACH algorithm remain energy as the major factor in selecting cluster head, it does not consider the cluster size and fault nodes having the impact on detection accuracy .

In this paper, we propose a mobile agent-based clustering data fusion algorithm in WSN . The basic idea is to divide all of the sensor nodes in the detection region into several clusters, control the size of the clusters using two cluster heads model, and remove the fault nodes through the partial results of data integration. Between the cluster heads, we use mobile agent for data fusion, and optimize the the path of the mobile agent. In this way, it can reduce energy loss effectively and prolong the network cycle.

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II. NODE MERGING ALGORITHM

We assume that there are n nodes need to fusion. The current integration result of cluster head is[a,b], and the detection result of node is[a_i,b_i]. When the cluster head receiver the data from each node, it first compares the lower bound of the data from normal node with the current lower bound from cluster head. If the lower bound is greater than the current lower bound, we define the lower bound as current lower bound. Otherwise, the current lower bound remains. And then the upper bound of the data from normal node is compared with the current upper bound from cluster head. If the upper bound is greater than the current upper bound, the current upper bound keep the same. If the upper bound is less than the current upper bound and greater than the current lower bound, then the upper bound is defined as the current upper bound. If the upper bound is less than the current lower bound, than the corresponding sensor is considered as a fault sensor.

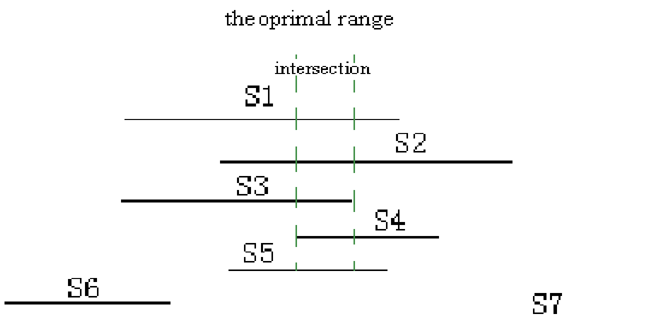

Fig. 1: The integration result of 7 nodes

In figure 1, it indicates the optimal range of the detection data from 7 nodes. S1∼S7 represent the seven sensor nodes. The length of the horizon represent the range of the detection data. The position of the horizon represent the size of the data. Figure 1 shows that the intersection of the detection data from all the nodes is the optimal range that we need.

III. THE ROUTING POLICY OF THE MOBILE AGENT

The routing of the mobile agent is actually to find a path with the shortest Hamilton circuit. In this paper, we can solve the problem using PSO algorithm. Assume d_{ij} is the distance between i and j. The decision variable is :

$$x_{ij} = \begin{cases} 1 & \text{if the mobile agent visits mode } i \text{ to } j \\ 0 & \text{otherwise} \end{cases}$$

The objective function:

$$minZ = \sum_{i,j=1}^{n} x_{ij}\, d_{ij} \tag{1}$$

The PSO algorithm derived from the process that the flock of birds is foraging. Each solution of optimization is imagined as a bird, called particle. Each particle is a solution of n-dimensional space. Its speed is the adjustment sequence that adjusts the original positions. It can form the new solution though position adjustment. The stare of the particle i is:X_i=(e_{i1},e_{i2},...,e_{in}). The velocity vector is:V_i=(v_{i1},v_{i2},...,v_{in}). The optimal state of the particle i is *Pbest*$_i$. The best state of the flock of birds is:*Gbest*$_i$. At the moment of $t+1$, the velocity and position update formulas of particle i are:

$$\begin{aligned} V_i^{t+1} &= \omega \times V_i^t \\ &+ c_1 \times r_1 \times (Pbest_i - X_i^t) \\ &+ c_2 \times r_2 \times (Gbest_i - X_i^t) \end{aligned} \tag{2}$$

$$X_i^{t+1=} X_i^t + V_i^t \tag{3}$$

$C_1$and C_2 are the learning factors, which express the dependence on current information. r_1 and r_2 are random numbers between 0 and 1. They are used to increase the randomness. ω is the inertia factor, which adjusts the search space.

We can think the position of the particle is a Hamilton path that contains all the cluster head nodes. So the solution space is the collection of all the positions. In this paper, the distance between the cluster head nodes, that the formula (1), is used as the objective function.

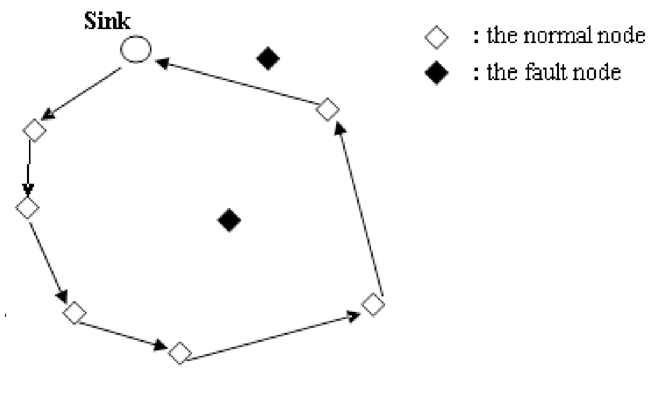

Fig. 2: The mobile agent-based model in wsn

IV. The improved algorithm of clustering based data aggregation

There are two processes in the cluster building phase, the stage of cluster head election and the stage of forming cluster.In order to build cluster head election mechanism, we use temporary cluster head, that in a cluster ,there are two cluster heads, the master cluster head and the sub cluster head. They form the master cluster and the sub cluster separately. At a certain stage, the temporary cluster heads will replace the functions of the master cluster head. We preset the temporary cluster heads when we do the wireless sensor networks layout.

A. the stage of cluster head election

In the initial stage, the temporary cluster heads make themselves as the new cluster heads, then enter the step (1) of the stage of forming cluster.

In cycle stage, according to the residual energy information, the temporary cluster heads designate the new cluster heads, inform the node, then enter the step(2) of the stage of forming cluster.

B. the stage of forming cluster

(1)In the initial stage, the sink collects the data from part of nodes and made a fusion. We can get the partial integration result[A,B], then sent to each cluster head.

(2)The new master cluster heads sent the information A about clustering.

(3)When all the nodes receive the information A, they record the received signal strength indicator(RSSI). They select the largest RSSI as their new cluster head, and compare their detection data with the partial integration result[X,Y]from their new cluster head. If the upper bound from their data is less than X, or the lower bound is greater than Y, it is a fault node. Otherwise, the node sent the request into the cluster to the cluster head.

(4)all the cluster heads count the numbers of their cluster nodes. If the number does not exceed the maximum number K, the master head assigns and sends time slots to its nodes. Then it selects its sub cluster head with the ruler of cluster head selection. After that, clustering is finished. If the number of nodes is greater than K(the cluster is named as temporary cluster), a sub cluster will appear in the temporary cluster. The master cluster head designs a sub cluster head in its cluster, and sends the massage about clustering again. The sub cluster head sends clustering massage B in the temporary cluster. All of the nodes in the temporary cluster compare the RSSI form A with it form B, and the cluster head who sends the greater RSSI will become their own cluster head.Then they send the request into the cluster to the cluster head.

(5)The master head and the sub head assigns and send time slots to their nodes. After finished the clustering, the WSN enters into the communication stage. When the communication finishes, the master cluster head become into the temporary cluster head automatically. In the final round, all the nodes sent their residual energy and data to the cluster head nodes. The WSN enters into the stage of clustering again.

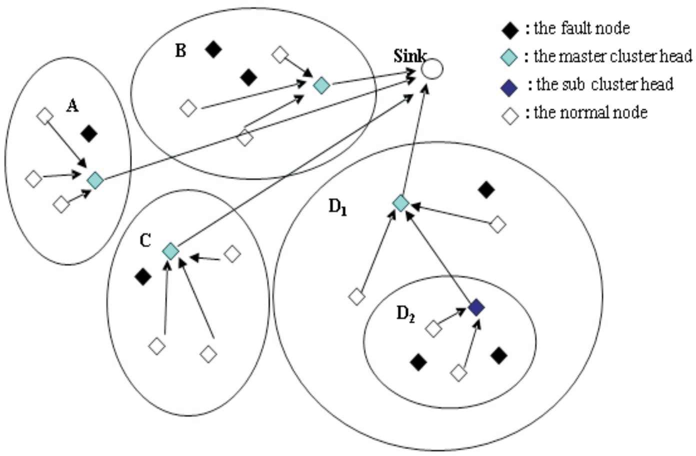

Fig. 3: The structure of the cluster

In figure 3, D_1 is the master cluster. D_1 is the sub cluster. In the data fusion, the sub cluster head 2 sends its integration result to the master cluster head 1, then the master cluster head makes the data fusion.

After the division of node,the sink node find out the path of the mobile agent at the cluster node,through the routing policy of the former chapter, and then successively migrate to cluster head node for aggregation, at last returning the result to the sink node.

V. Imitation and performance analysis

A. Comparison of the path loss

Aim to find out the difference of the total communication distance between mobile agent and non-mobile agent, we set 11 imitation experiments(nodes in the clusters ranges from 10 to 60), we can find out that the angented ones decreases path attrition in some degrees,which we can see from figure 4.

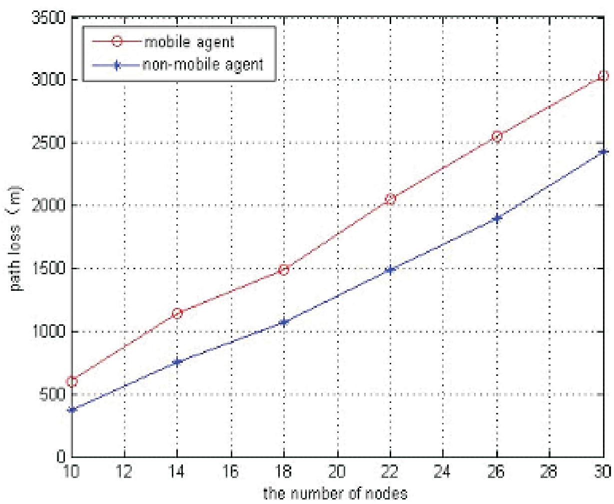

Fig. 4: The relationship between the path loss and the number of nodes

B. Comparison of the cluster size

We compare the LEACH protocol and CBPD for the size of clusters. Simulation conditions are: there are 240 nodes. In each clustering, we get 8 master cluster head nodes, and each cluster has an average of 30 nodes. Set K=50, in the simulation, we get 400 master clusters for each algorithm, and get 91 sub clusters. Figure 4 shows that the CBPD algorithm can homogenize the size of the clusters, and ensure that the energy of the cluster head consume evenly. It is favorable to prolong the network lifetime.

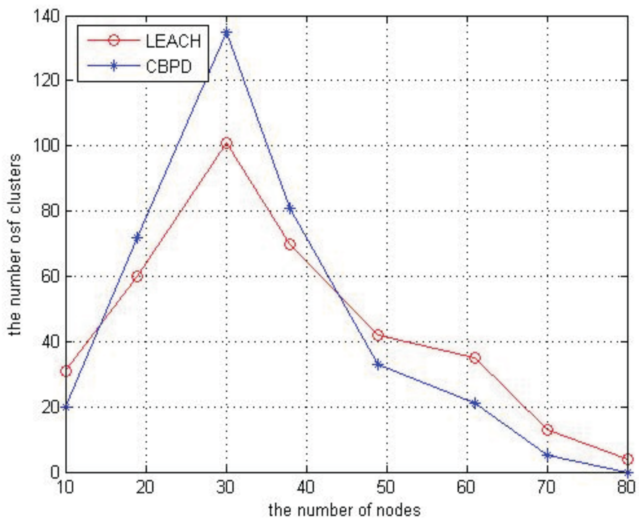

Fig. 5: The distribution of nodes in the cluster

VI. Conclusions

According to the results of part aggregation, we can reject error nodes, improve the accuracy and decrease mistakes through the process of the cluster division.The mobile agented cluster head make the agreegation at the cluster nodes, which decreases data redundancy. And imitation results shows angented do decrease path attrition, the algorithm also can effectively control the cluster scale, which extends the network lifetime of WSN.

Acknowledgment

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