Topology Control Based on Double Cluster Head Ellipse Model in WSN

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ABSTRACT: Aiming at the problem that the cluster head node overload and cannot effectively control the edge node based on routing protocol in wireless sensor networks. We designs a kind of ellipse model with double cluster heads and uses Matlab to carry on the network simulation experiment. Through the analysis of simulation results and comparison with LEACH protocol, it is proved that the non-uniform clustering routing protocol with double cluster heads which can improve the balance of network energy consumption. This idea provides a new direction for the research of WSN architecture.
KEYWORD: wireless sensor network; clustering differentiate; elliptical mode

1 INTRODUCTION

The wireless sensor network has the features with the low price, disorderly infrastructure, the strong robustness and the strong topological flexibility with the high dynamic network, doing well in all areas make it have received much attention. However, especially for the nodes near the base station due to limited energy and excessive load, they usually only have a short life cycle. At this time, although there is still a lot of residual energy in the network, this phenomenon will significantly reduce the network's communication and coverage. It even lead to paralysis of the global network and resulting network cannot meet the application requirements to provide services (ZHANG Xue et al, 2007) (Milos et al, 2014).So how to build low-power and better fault tolerance performance of the WSN topology from the perspective of the system has been a research problem.

Moreover due to the randomness of the self-organizing point of wireless sensor node, the boundedness of single point detection (Alessia et al, 2013), the edge node detection is especially important, which makes the topology control has an important role in improving the performance of wireless sensor networks.

In wireless sensor networks, Leach (low energy adaptive clustering hierarchy protocol and LEACH Protocol) is the first hierarchical routing protocol based on multi cluster structure. Subsequently, many layered protocols, such as teen, PEGASIS are mostly on the basis of it (ZHANG Ren-shang et al, 2014). It is a widely used and more mature routing protocol for wireless sensor networks. Its basic idea is to select the random cycle of the cluster head in equiprobability. The energy load of the whole network is evenly distributed to each node so as to achieve the goal of reducing the network energy consumption and prolong the network lifetime (Ye M et al, 2005). But there is a fatal flaw: the cluster head of each cluster is different from the base station in the cellular network. It has no special hardware and there is energy problem. Therefore, it is likely to become a bottleneck node of the network so that it is difficult to guarantee QoS (Assaf B Y et al, 2004). Although a variety of clustering algorithm's proposition can guarantee some QoS, it cannot fundamentally solve the problem.

For this purpose, this paper presents a WSN topology control model based on double cluster heads ellipse model (DHEM). Its main characteristics is adding a sub cluster head in a single unit of cluster. The sub cluster head processes communication between the cluster members of cluster head and the first cluster head forward to its data packets in order to its next forward. It can lighten the burden of cluster head. Due to the existence of cluster head, channel spatial reuse rate increase and single cluster size is not completely decided by the wireless transmission power of cluster head. It solves the contradiction between throughput and cluster size, energy saving and cluster head function.

Second, this paper constructs the model is not the traditional circular model, but to build dual cluster head nodes form an elliptical model and model pa-

rameters in multi hop mode to transmit to the base station, between nodes without need to analyze the original data only transfer parameters, greatly reducing the energy consumption of nodes, but also effective on the edge node of detection and control, improve the wireless sensor network local outlier detection efficiency and accuracy.

2 DCHE MODEL CONSTRUCTING

The paper proposed the elliptical mode made by data received from double-cluster and Clusters in ordinary nodes. As long as the node's data within the scope of the ellipse, so that won't be considered that something wrong with outlier because of some point be farther to cluster or the nearby density be sparse. As for wireless sensor networks, the resources of the communication cost to several orders of magnitude larger than the calculation cost of resources, also ensure the accuracy of precision save node resources under the condition of overhead (TANG Jian et al, 2006) (Heinzelman WR et al, 2002).

This paper adopts outlier detection algorithm using elliptical mode to describe the distribution of the node in WSN, to avoid the space lost because of traditional algorithm for outlier data attributes deviating from the original features, so that reduce the accuracy of detecting outliers

To make the hypothesis as the wireless sensor network deployed in heterogeneous environment detection area made by m isomorphism of sensor nodes, use the undirected graph G(G=(S,L)) to show the topological structure of the network, S represent the sensor nodes aggregate in the network, and L represent the communication link aggregate connected two nodes in the radius, R represent the communication radius between the nodes, $d(s_i, s_j) \le R$ is for instance between the nodes.

2.1 *Selection of clustering and cluster head.*

Using HEED algorithm for choosing cluster heads and standby cluster was selected this paper. HEED algorithm determine the probability of cluster heads by nodes left energy, the initial probability of nodes be chose to cluster head shows as follows. Therein-to, CH_{prod} shows the initial value, with the C_{prod} shows the expected proportion of cluster head, and the $E_{resudual}$ shows the left energy of node.

$$CH_{prod} = C_{prod} \times \frac{E_{residual}}{E_{\max}} \tag{1}$$

The node use random number n(0≤n≤1),when n less than CH_{prod} .n would be selected. Not hard to see, the node left more energy, the probability get higher, but HEED still hardly avoid the low energy be selected to the cluster head, instead the higher one become the cluster member.

We can use node i left energy $E_r(\mathrm{i})$ compared with the neighborcount node average energy $Avg(\mathrm{i})$,if $E_r(\mathrm{i}) \ge Avg(\mathrm{i})$,so that i could be the standby cluster head, otherwise i become cluster member, the limit condition be as formula(5-5), there into j is i's neighborcount.

$$E_r(\mathrm{i}) \ge Avg(\mathrm{i}) = \frac{\sum_{j=1}^{neighborcount} E_r(\mathrm{j})}{neighborcount} \tag{2}$$

In order to avoid the overhead of multiple iterations, let standby cluster head wait $T_c(\mathrm{i})$ for certain time, if the cluster head broadcast hadn't be received during this time, i would be the cluster head and go to the cluster head broadcast. At the same time, $T_c(\mathrm{i})$ would be set in inverse proportion of $\cos t(\mathrm{i})$,it can be used to make low cost, with the more-neighborcount-node be cluster head precedently. The formula of $T_c(\mathrm{i})$ and $\cos t(\mathrm{i})$ as follows shows, there into t is the constant, j be neighborcount for j.

$$T_c(\mathrm{i}) \begin{cases} \dfrac{t}{\cos t(\mathrm{i})}, \cos t(\mathrm{i} > 0) \\ t_{\max}, \cos t(\mathrm{i}) = 0 \end{cases}, \ \mathrm{cost}(\mathrm{i}) = \sum_{j=1}^{n} \frac{1}{dist(\mathrm{i}, \mathrm{j})} \tag{3}$$

2.2 *Elliptical mode.*

The elliptical model can describe flexibility receiving the data, changing trend, and many kinds distributions of data. In this paper, by using the elliptical mode depicting the normal structure of each node in the network to collect data, the related theory of elliptical mode shows as follows:

The normal node would send the message to the cluster head, from node i power information be turned as standardization to X, from time to Y, use midpoint of main-cluster-head as a point to set origin coordinate system, with node s_i correspond (x_i, y_i) o main-cluster-head node coordinate(c,0),(-c,0) form to elliptic E_i .

Normalized formula: $x_{new} = \dfrac{x_{old} - \min}{\max - \min}$ (with the same formula for Y)

In the network,the node build the elliptical mode depicting its data distribution as $E_1, E_2, ..., E_m$,and transmit elliptical data to the cluster head respectively. The cluster head get the elliptical collection with-

in the cluster $E(\{E_1, E_2, ..., E_m\})$,make it to synthesis as a single elliptic in the end, use $E_1, E_2, ..., E_m$ to E' ,and all the nodes within the elliptic ,with the elliptic equation is $\frac{x^2}{a'^2} + \frac{y^2}{b'^2} = 1$.

2.3 *Algorithm description.*

Input: wireless sensor network was made by m nodes $\{s_1, s_2, ..., s_m\}$, when node s_i receive the new data x_i,

Set R_{intra} as the radius within the cluster, node i broadcast the message Hello use the radius, the ID that include node in message Hello, and message like left energy $E_r(i)$,receive the node of message Hello and then answer.

Calculate $Avg(i)$, make a decision about being cluster-head.

The node i met the conditions of cluster head nodes, after waiting $T_c(i)$,end the broadcast message include $cost(i)$ to the node within R_{intra} and cluster member node j select the node j from the message which $cost(i)$ be minimum as cluster-head to clustering.

Set the experiment, the normal nodes in clusters would collect ω data send to all cluster-heads, set the cluster-head and standby cluster as focal point ,and use the data sets be collected from normal nodes to build the elliptical modes $E_1, E_2, ..., E_m$,and now all the node within the cluster is in elliptic.

The main cluster-head make all elliptic as a single one, means $E_1, E_2, ..., E_m$ synthesize E', in a meanwhile, the main cluster-head send nodes' ω data to the standby cluster, use distance to divide the node to take over.

3 EXPERIMENTAL ANALYSIS

For evaluating the experiment result, we use Matlab programmed a Sensor network simulator. The concurrent operation of nodes realized through the discrete event simulation. We use data number of bytes that each node sent and received on average to evaluate algorithm communication efficiency and energy-efficiency. According to that energy be sent and received is the most important factor for node energy costing, and we believe that evaluate the effectiveness of algorithm like that will be appropriate.

In simulation environment, there would be 40 nodes be put random into an area as 100m×100m,with the nodes communicate bound is 10m.These nodes were divided into 8 clusters, and every cluster node could be allowed to communicate to base station directly. Node data be generated by synthetizing.

Suppose that the nodes wireless communication is reliable, the failure rate of data transmission is 0.We set time-window size is 10 samples (means node makes time series n=10). All the data is at least 50 times since the independent operation of the average. We compare the LEACH algorithm and the method proposed in this paper.

As shown in Figure 1, the DCHE algorithm is better than LEACH in the node survival situation. In the simulation experiment, the first death node of DCHE appears in the 110 round, while the LEACH is the 80 round. And it is obvious that the node survival time of DCHE algorithm is much larger than that of the LEACH algorithm.

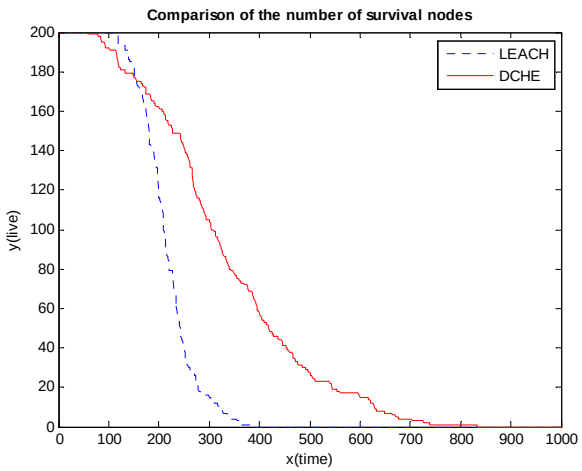

Fig1. Comparison of the number of survival nodes

The network energy consumption of LEACH and MRDC is shown in figure 2. LEACH in the 220 round of energy consumption has reached the network saturation and MRDC can be extended to the 520 round, this shows that the energy consumption rate of MRDC is slower than LEACH.

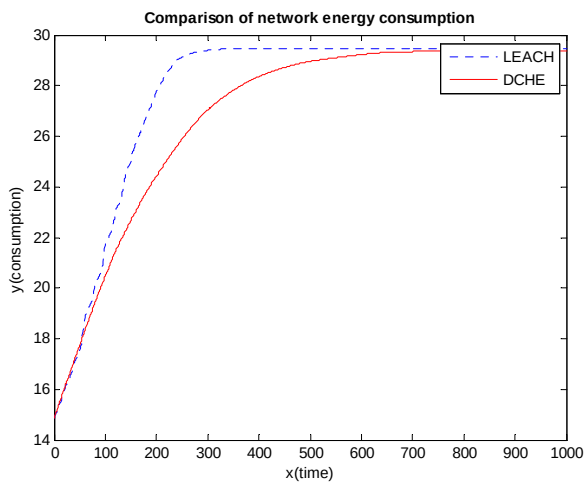

Fig2. Comparison of network energy consumption

In the two algorithm, the data amount received by the base station is changed with time. As shown in Figure 3, it is clear that the amount of data received by the DCHE algorithm is far greater than the amount of data received by the LEACH algorithm.

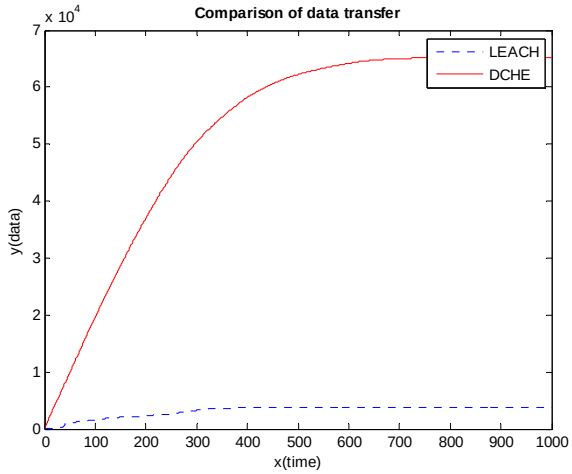

Fig3. Comparison of data transfer

4 CONCLUSION

We propose a multi hop routing protocol based on double cluster heads of which the core idea is to select a large residual energy node as the cluster head in each cluster and produce multi hop inter cluster routing between each pair of cluster head. Thereby it can lighten the burden of cluster heads, balance the network energy consumption and prolong the network life cycle. Although the results obtained from this study are satisfied, it also has problem at the same time. We should consider the influence of the motion state and position relation of the main cluster head on the topology control due to the preparation of the dynamic relationship between the cluster head algorithm acceptor. It has effect on the long axis of the ellipse while it has no influence on the short one. So that it influent the determination of short axis direction edge node. This issue will be further discussed in the future.

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