Dynamic Nodes Partition Algorithm for Ad Hoc Network

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Abstract: A dynamic nodes partition algorithm for the Ad Hoc network is proposed. Firstly, Roam cluster method is used to cluster 926 random nodes in a square region. Subsequently, the central moving model based on the simulated annealing algorithm and the least circle overlay model is constructed to remove the network redundancy of the circle number and circle radius respectively. Simulation results show that the algorithm can effectively maintain the stability of network structure and increase balancing capabilities of Ad Hoc network load. The future work is to study how to improve the adaptability for the application in the complicated areas.

Key words: Ad Hoc network; dynamic notes partition; network redundancy

I. INTRODUCTION

As people have a desire to get rid of the shackles of wired networks and to communicate freely anytime and anyplace, wireless network communication has been rapidly developed in recent years [1]. In order to achieve communications in areas without fixed base station, Ad Hoc network technology come into being as a new network technology in Refs. [2-3]. Mobile Ad Hoc network is a self-organizing wireless network that exists without the support of fixed infrastructures, and provides an effective solution for military communications, medical communications, disaster relief and temporary communications [4-5].

The most effective way to achieve rapid distribution of the entire network and dynamic reconstruction after changes of network topology is to use clustering algorithms [6-9], such as the smallest ID algorithm [10] and the highest degree algorithm [11]. The advantages of the former includes that it is simple, convenient to achieve and its convergence speed is rapid. But equally the disadvantages are clear that the number of cluster heads is large, the update frequencies are high and it doesn't consider the load balancing of networks. The advantages of the latter includes: the number of cluster heads is correspondingly small, the delay of packet delivery is decreased, but the disadvantages are that the renewal rate of cluster heads will rise when nodes mobility is strong, and will result increase in expenses of maintaining the networks.

Whichever the smallest ID algorithm, the highest degree algorithm, or the other methods, it only consider one aspect of the network performances, so we need an integrated clustering algorithm which considers various factors. In this paper, a dynamic nodes partition algorithm for Ad Hoc network is proposed. This work was also aroused from the 3th National Post-Graduate Mathematical Contest in Modeling (NPMCM) [12]. Firstly, the roam cluster method is used for nodes clustering. Then the central moving model and least circle overlay model are established to remove the network redundancy. After the connectivity is tested, the dynamic algorithm could be obtained. We also use the simulated data to verify the validity of the algorithm.

II. ISSUE DESCRIPTION

Issue: For Ad Hoc network, node density has significant impact on network partition. On one hand, if the nodes are too intensive, there will be too many connection jumps between the source node and the destination node, and this produces redundancy. Thereby it increases the burden and is not conducive to the security of the network. On the other hand, if the nodes are too sparse, maybe the source node cannot find the destination node in a period of time, and this may cause long delay or packet loss. In this study, we just take into account a square region (1 000 × 1 000) including 926 nodes [12], which randomly dispersed and is showed in Figure 1. We need to use some circles with certain radius that overlap to cover the nodes in this square region. The radius of the adopted circles can not be too large or too small. If the radius is too large, the power of source node must increase. However, the total energy of all nodes is limited. So this will inevitably lead the survival cycle of the network become shorter. If the radius increases, the number of nodes that connect the neighboring region will be fewer. Then it may result in a greater packet loss or time delay, especially for the dynamic application. So it is a challenging work to acquire the appropriate result.

Goal: to obtain the minimum of the sum of all circles' radiuses.

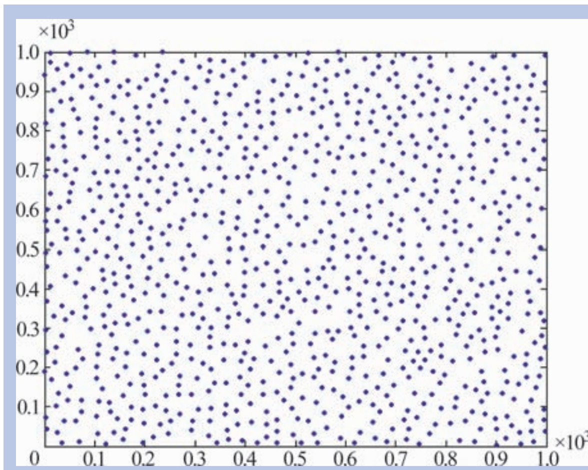

Fig.1 DREAMSCAPE-based control plane

III. DYNAIC NODES PARTITION ALGORITHM

3.1 The algorithm description

The length range of the circles is restricted in 50 ~ 100. The core idea of this algorithm is summarized as follows. Firstly, we use roam cluster method to assign the 926 nodes into different circles (i. e. clusters) and also find the cluster heads. Then we establish one-jump coverage area respectively, using every cluster head as the centre of the circle. This will produce a lot of network redundancy, which mainly is consisted of two parts: circle number redundancy and circle radius redundancy. Then we construct the central moving model based on the simulated annealing algorithm and the least circle overlay model to remove network redundancy. The detailed flow chart of the algorithm is exhibited in Figure 2.

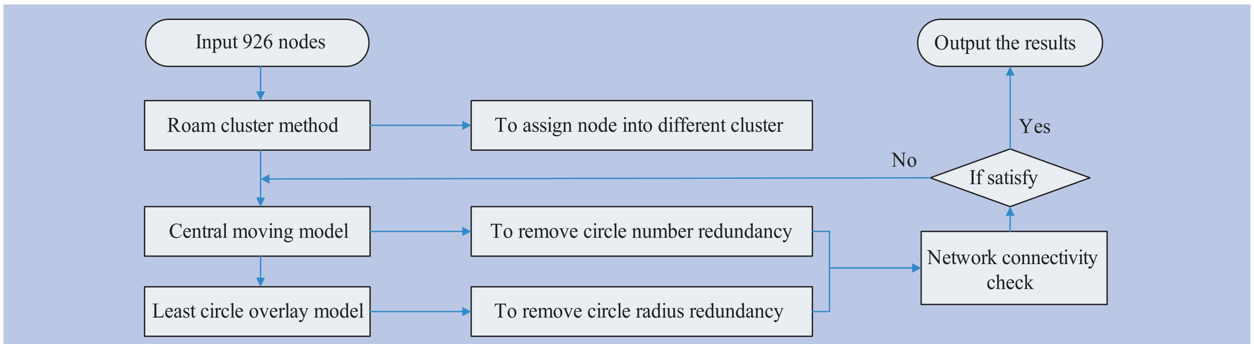

Fig.2 The flow chart of the dynamic nodes partition algorithm

3.2 Roam cluster method

1) The original 926 nodes are arranged by sort ascending according to the *x*-coordinate. Then they form a 926 × 2 nodes matrix $\boldsymbol{A}$, which the values of each row denote the *x*-coordinate and y-coordinate respectively. Initialize the zero-matrix $\boldsymbol{B}$ (100 × 2), zero-matrix $\boldsymbol{C}$ (926 × 2), the radius of one-jump coverage area $R_0(R_0 = 100)$ and the number of nodes $N(N = 926)$.

2) Put the first node A_1 of $\boldsymbol{A}$ into $\boldsymbol{B}$ and calculate the gravity center O of $\boldsymbol{B}$. The n compare the distance d between $A_k(k = 2, \cdots, N)$ in $\boldsymbol{A}$ and gravity center O with R_0 in turn. If $d \leqslant R_0$, A_k will be put into matrix $\boldsymbol{B}$. Accordingly, the gravity center O will be regenerated using all nodes in $\boldsymbol{B}$. If $d > R_0$, A_k will be put into $\boldsymbol{C}$. When $k = N$, the number of nodes N will be regenerated using the number of $\boldsymbol{C}$.

3) If there is no one node in $\boldsymbol{C}$, go to 4). If not, the matrix $\boldsymbol{A}$ will be replaced with matrix $\boldsymbol{C}$. The nodes in matrix $\boldsymbol{B}$ and the gravity center O will be conserved. Then matrix $\boldsymbol{B}$ will be initialized and the algorithm returns to 2).

4) Make each gravity center O as the center coordinate of one-jump area. Educe the number of centres and clusters.

The result of nodes partition method using roam cluster is shown in Figure 3.

3.3 Central moving model

In this section, a central moving model based on the simulated annealing algorithm is proposed to remove the redundancy of circle number. There are M clusters in all. For each certain one-jump coverage area $r_m(m = 1, 2, \cdots, M)$, the centre coordinate

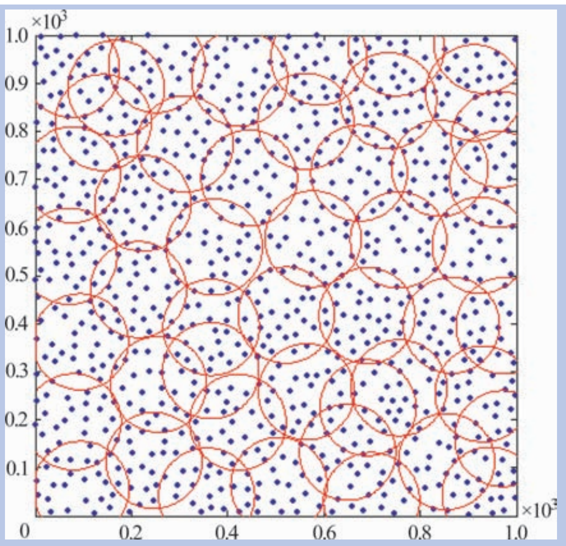

Fig.3 Nodes partition by roam cluster method

is (x_m, y_m), the number of internal nodes is N_m. We produce a small increment Δx_m, Δy_m randomly, then the center coordinate relocates to $(x_m + \Delta x_m, y_m + \Delta y_m)$. Then count the number of nodes in this new circle. If the new circle can not contain the original N_m nodes, then remove the center to $(x_m + \Delta x_m, y_m + \Delta y_m)$ with a small probability; if the new circle contains the original N_m nodes or even more, then remove the centre to $(x_m + \Delta x_m, y_m + \Delta y_m)$ with a large probability. If the all nodes in one cluster are also included in the other clusters, then remove this circle. The result of the central moving model based on the simulated annealing algorithm is shown in Figure 4.

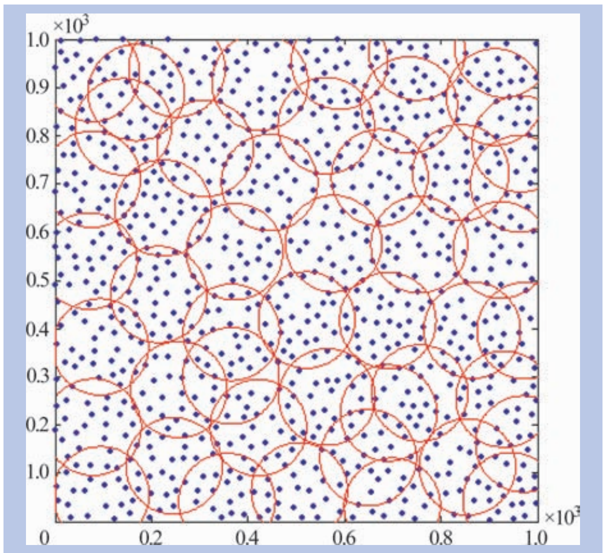

Fig.4 The result of central moving model

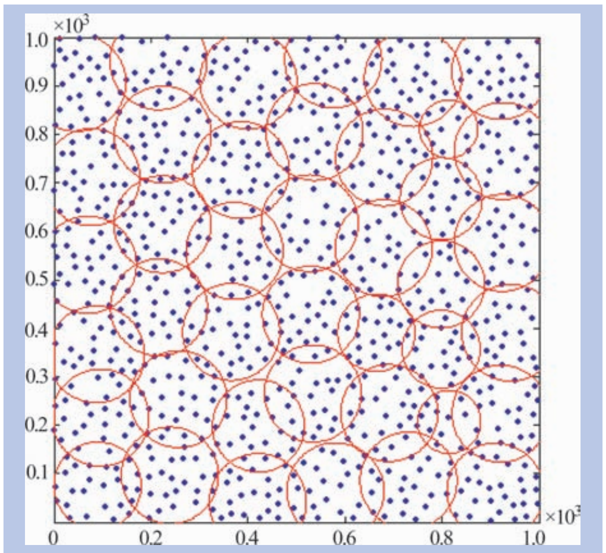

Fig.5 The result of least circle overlay model

3.4 Least circle overlay model

For each one-jump coverage area R_m, whose center is $o_m(x_m, y_m)$ and radius is r_m, connect o_m with each internal node $k_1, k_2, \cdots, k_{N_m}$. In this way, each line can intersect with the circle on the point $P_i(i=1, 2, \cdots, N_m)$. Let d denotes the distance redundancy: $d_i = |o_mP_i - o_mk_i| = |r_m - o_mk_i|$. Then the aim function is defined as follows: $d = \sum_{i=1}^{N_m} d_i$. When d achieves the minimum, the corresponding center (x_m, y_m) and radius r_m is recorded. After the above treatments, we need to add restriction to the results of nodes partition that all nodes must have connectivity. If the one-jump coverage area R_m intersects with around j coverage areas $R_i(i=1, 2, \cdots, j)$ and the intersect areas are $A_i(i=1, 2, \cdots, j)$ in turn, we define B_i = {node number in A_i}. If $B_1 \cup B_2 \cup \cdots \cup B_n \neq \varnothing$ is true, the restrictions can be satisfied. If not, increase the radius of the one-jump coverage area R_m, to meet this condition. If it can not be satisfied although the radius of r_m has been increased to 100, then randomly increase the radius of the adjacent $r_i(i=1, 2, \cdots, j)$ until it can be satisfied. After the above treatments, the result is shown in Figure 5.

3.5 Results comparison

The algorithm is performed in a certain order: first roam cluster method, then central moving model and last least circle overlay model. The results comparison of these three different processing are showed in Table I. After the processing of roam cluster method, the result consists of 48 circles with radius 100. So the radius sum is 4 800. It is clearly in Figure 3 that the radius $R=100$ is inapposite and there are many redundancies. The central moving model can effectively remove the redundancy due to the overlapping of the circle, and reduces the circle number (Figure 4). It only needs 40 circles with radius 100, and the radius sum is 4 000. After the processing of least circle overlay model, the result consists of these circles: 30 circles (radius 100), 2 circles (radius 98), 2 circles (radius 95), 3 circles (radius 87), 2 circles (radius 77), 1 circles (radius 65) and 1 circle (radius 59). The radius sum is 3 925.

Table I Results comparison after three different processing

After this processing	Radius (r) distribution results (number)						Radius sum
	[50, 60)	[60, 70)	[70, 80)	[80, 90)	[90, 100)	=100	
Roam cluster	0	0	0	0	0	48	4 800
Central moving	0	0	0	0	0	40	4 000
Least circle overlay	1	1	2	3	4	30	3 925

Note: [50, 60) means that $50 \leq r < 60$

IV. CONCLUSIONS

This work proposes a dynamic nodes partition algorithm for Ad Hoc network, which can quickly accomplish the dynamic partition for random nodes. The next step is to study how to improve the adaptability of Ad Hoc network for the application in complicated areas.中国通信

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Biography

Liu Chengyu, received his Ph.D. degree from Shandong University, China in 2010. He is now a post-doctor at Shandong University. His research interests include network intelligence and communication for physiological signals. Email: bestlcy@sdu.edu.cn