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An Analysis of Topology Based System Control Clustering Algorithm in Wireless Sensor Networks

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Abstract

Topology control is a basic issue in wireless sensor networks. It has great significance to establish the hierarchy clustering topology for improving the network performance. Characteristics of the immune system, such as memory learning, feedback regulation and distributed autonomous without a center, provide a novel approach to the issues that exist in the clustering topology control in wireless sensor networks. Mechanism of immune system based topology control clustering algorithm is presented for wireless sensor networks in this paper. It mainly contains the definition of the immune problem, the algorithm's design and implementation, simulation test. Through the simulation on the performance of clustering optimization, the algorithm shows good clustering performance based on the mechanism of the immune system.

Keywords: Wireless sensor networks; Immune system; Clustering topology; Cluster compactness

Introduction

Wireless Sensor Networks (WSN) are integrated with microsensors, data processing units and short-range wireless communications which are randomly deployed in the area for detection. The self-organizing network system is formed by tiny nodes through wireless communication. Topology control is a basic issue, the study is to eliminate unnecessary communication link between the nodes and to form a data forwarding optimal topology by power control and backbone node selection under the precondition of coverage and connectivity of the nodes. The force does not cause the entire system to collapse due to the exception of some nodes, which is very suitable for rapid construction in special moments and special environments. Therefore, Wireless sensor networks have broad application prospects.

Compared with traditional wireless networks, wireless sensor networks have different design goals. The former is grouped by the data of the transmitted user. The latter is centered on the monitoring data of the external environment and needs the new network architecture support. The main problem of sensor network topology control is to satisfy the network connectivity. Stable network topology should have the characteristics of scalability and dynamic adaptability but not being based on the fixed topology. Many challenging issues are presented for wireless sensor networks in the aspects of the basic theory and engineering technology of hierarchical network topology establishment. The key of wireless sensor network will directly affect the performance of routing transmission [1].

The wireless sensor network has the characteristics of no-center self-networking, dynamic change of network topology and energy limitation, as well as the working environment. Reliability of packet transmission is an important index to evaluate the performance of wireless sensor networks. Stable topology based routing is established to realize reliable packet transmission which gives consideration to the balance of energy consumption and low transmission delay, and so forth. Constructing adaptive network topology is of great significance to improve self-organizing ability, adaptability, and robustness of network [2]. According to the biological, the immune system has the characteristics of openness, distribution, dynamic and robustness [3-5], and memory learning, feedback regulation, and no center. The information processing mechanism, such as the mechanism of cloth self-government [6], provides a novel solution to the problem of wireless sensor network topology control.

The immune mechanism provides new research ideas and methods for the cluster topology control of wireless sensor network and has highlighted the better clustering effect. At present, the research in this field is in the initial stage, and the topological clustering and optimization control need to study further, both at home and abroad.

Some scholars [7] have done preliminary research work. In the literature [8], the author established a mathematical model of node frequency control by using artificial immune system, and the minimum energy consumption topology control method for wireless sensor network was presented based on the artificial immune response. Furthermore, Zhang et al., [9] proposed the data fusion mechanism of the immune system to guarantee the high reliability and low redundancy. Salmon et al., [10] represented a cooperative and intrusion detection mechanism, and the immune intrusion detection mechanism of wireless sensor network tree structure was also obtained by using the inspiration of the human immune system. The literature [11] proposed a new cluster topology model and immune mechanism, which has strong fault tolerance. Meanwhile, according to the immune mechanism, the self-repair system can diagnose and repair the node and link fault, which lead to the instability of the system, Bokareva et al., [12] proposed the fault tolerant structure SASHA for wireless sensor network based on biological immune mechanism.

Jabbari et al., [13] and Atakan et al., [14] build network model by using the clone selection in the immune theory, affinity, and immune network theory, where self-learning, self-organization, memory and

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information processing of the biology immune system or neural-immune system have been simulated.

This paper presents a wireless transmission based on the mechanism of the immune system. The topology control algorithm of a sensor network cluster is optimized. The cluster topology control algorithm is discussed, which presents the definition of immune parameters, and the realization and optimization of cluster topology control. The main contribution is the definition, optimization and simulation analysis of clustering based on the immunity systems.

Cluster topology control algorithm based on immune system mechanism

The immune system, based on immunological learning, memory and recognition methods, is a grid control system with dynamic balance function, which has been restricted and stimulated by cloning and self-identification. Further, we obtain the initial antibody group with k-means and distance factor, where the initial cluster head node is a certain number of an ordinary node according to the probability. The affinity of antibodies and antigens is calculated by using node energy and affinity function of distance factor, and following we select some excellent antibodies to obtain memory and variation. The optimal antibody solution is determined by the termination condition.

Suppose the antibody is the cluster head node of the wireless sensor network, i.e., the solution to the problem. The antigen is a sensor node of wireless network random that is the problem to be solved. Antigenic recognition has defined the optimization of cluster topology of the wireless sensor network, which is to solve the optimal cluster head node and topological structure. Antigens correspond to nodes in the network, whereas antibodies correspond to cluster head node. The process of antigenic recognition is the connection between the cluster head node and its neighbor node information exchange. The initial group is generated the number of cluster head nodes random (initial antibodies). These corresponding nodes are the common nodes randomly distributed in the network, including their own location information and energy information.

The degree of affinity reflects the degree of matching between antigens and antibodies, and antibodies and antibodies. The larger the degree of affinity, the more antibody matches antigen. The affinity function is:

$$f(i,j) = dist(i,j)^{*} \qquad (1)$$

The affinity function is defined as the distance between the current node and all cluster head nodes. The farther distance from the cluster head node, the lower the affinity. The affinity reflects the degree of clustering adding cluster head node. In addition, the encoding method is based on the natural numbers, and the memory test library is composed of the candidate optimal cluster head by selecting the antibody with high-affinity value.

In the following, we present the steps of clustering topology control algorithm based on immune system mechanism.

First, we can construct the initial antibody group by using randomly the fixed probability to select cluster. Next, we calculate the affinity of antibodies and antigens defining the affinity function. Moreover, we recalculate the affinity and also select the antibodies with good performance into mutation. Finally, the optimal antibody solution is obtained according to the conditions which the cluster has good compactness, a large distance between clusters and energy consumption. The specific steps of the algorithm are as follows:

Step 1: Set the basic parameters of the immune algorithm and initialize

Step 2: Antigen recognition. Antigen recognition is equivalent to whether the cluster head node can establish contact with its neighbors, which produces initial antibodies. We present the initial antibody that a certain number of ordinary nodes are randomly selected as the initial cluster head node. Then the new subcluster is obtained by use node energy and distance factors.

Step 3: Calculate the fitness. Define the affinity function of the algorithm, and then use the affinity function to calculate the affinity of antibodies and antigens. The distance between the remaining nodes of the network and the initial cluster head node is also calculated. Further, use k-means thought and classify the nodes near the cluster head node as one, and then the initial antibody group is

$$N_i \in CL_k \, if \;\; min\left\{dist(i,k), i = 1, 2, " , I, k = 1, 2, " , K\right\} \qquad (2)$$

Step 4: Generate memory. Construct judgment condition

$$\left\{ ¦ \, d_{ij} \;, \; \overset{n}{\underset{i=1}{j}} = 1, 2, N \right\} > \Phi$$

The corresponding cluster is selected by the threshold set, which makes it a candidate optimization cluster head in the memory library.

Step 5: Use crossover and mutation to produce a new generation of antibody groups. According to the results of antibody and antigen affinity, we select the antibody, which the affinity is higher the threshold of the valve, to ender the next iteration, making the proliferation and inhibition of the antibody. Therefore, a new generation of antibody populations can be generated by the crossover and mutation of antibody gene. The network node is encoded by natural numbers and $i$is the natural number encoding of the node $N_i, i \in (1, 2, " \, n)$. Further, the antibody of the original memory bank can be intersected and mutated, and the modified antibody of the memory bank is also modified by the following formula: $- \, i + \;\; r, i + \;\; r < \;\; n$

Communication model is based on the clustering topology, and the initial energy of the node is set as 1000 nJ. The model of the energy consumption model and parameters

$$\varepsilon_{amp} \;, \; E_{fuse}, \; E_{elec} \;, \; E_{tx} \;\; and \;\; E_{rx} \qquad (15)$$

The size of

$$i' = \text{®}_i \, r, i + r > n, i - r > 0 \qquad (3)$$

$i + 1$, otherwise

Where r is natural number random. A new antibody group is formed with the antibody of a new one and original memory bank. According to the formula of affinity function

$$f(i,j) = n\frac{e_i}{e} + \gamma\frac{dist(i,j)}{dist(i,j)}$$

We recomputed the affinity of antigen and antibody. Based on (3), the new antibodies are deposited into memory.

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Step 6: Set terminate condition and output the optimal solution. When the network meets the condition of iteration

n and min d_{ij} it stops iteration and output the optimal solution, otherwise, go to step 4

Step 7: Confirm the clustering of the head information. The antibody in the final antibody library is selected as the cluster head nodes and exchanged packets with the member nodes to confirm the clustering

Test

In this section, we can present the simulation analysis test. First, the assumption conditions are as following:

(1) The network nodes are static

(2) Each node location is known

(3) The initial state of the nodes is equal; each has the same parameters and initial energy

(4) The network node in full-duplex work mode

(5) The nodes are randomly uniformly distributed within the rectangle; the destination node is located in the lateral

Source packet is set with 2000 bits. The fault node is defined as the node which energy consumption achieves the initial threshold value δ. The network's life cycle is defined as the period from the network beginning to run until the moment that 10% of the nodes in the network run out of energy. The sensor data of the network node is acquired and transmitted periodically. The node reconstructs the received coded fragments into the source packets at a certain interval $\otimes t$.

Next, we present the main simulation based on the network clustering of immune mechanism. Figure 1 shows the random distribution of network nodes. The simulation test has the 150 nodes in (200,200), which the distribution mode is randomly deployed in the region. The target node is located in the right coordinate of the region (200,100). Figure 2 shows the cluster head node which is randomly selected at the initial stage of clustering. According to the k-means algorithm, the initial cluster topology is formed via the distance factor.

Figure 3 is a cluster of wireless sensor networks that immune mechanism is mutated and optimized multiply. From the comparison between Figures 2 and 3.

We can show that the network clustering based on the immune mechanism is more uniform and the effect is more optimized.

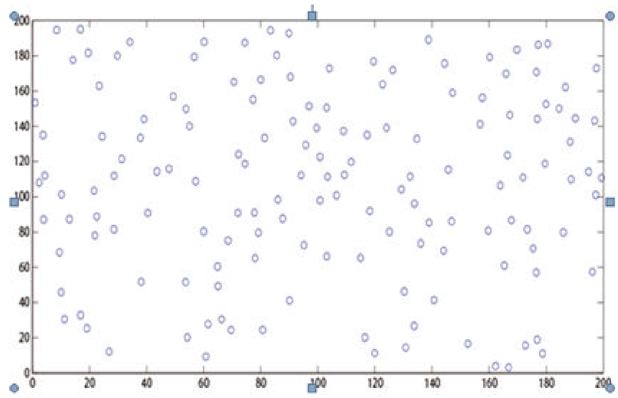

Figure 1: Randomly deployed network nodes.

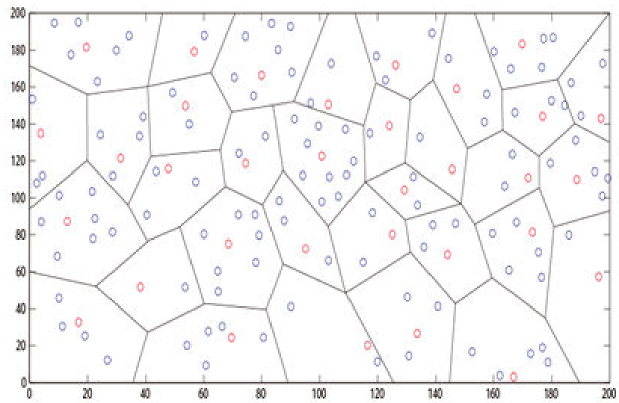

Figure 2: Initial clustering not based on immune mechanism.

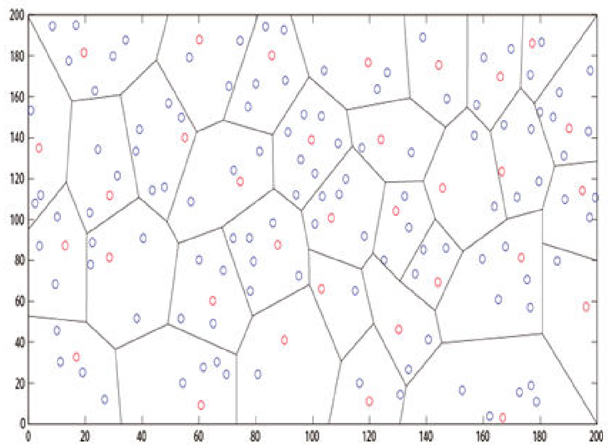

Figure 3: Immune mechanism based optimization clustering.

Conclusion

The structure of hierarchical network topology is a key to wireless sensor network transmission routing, which can directly affect the performance of the routing transmission. Topology control is a basic problem in sensor networks. The biological immune system is the information processing mechanism which has the memory learning, feedback regulation, no-center distributed autonomous mechanism. It provides a novel approach for wireless sensor network topology control. This paper presents wireless sensor network clustering topology control algorithm based on the mechanism of the immune system. This paper mainly includes the definition, algorithm design and implementation of related issues of immune evolutionary mechanism in the scenario of wireless sensor networks. Simulation of the network clustering performance can be tested. The results have shown that the mechanism of the immune system applied to cluster in wireless sensor network has good clustering performance.

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