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Improvement of LEACH Protocol Based on Genetic Simulated Annealing Algorithm

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Abstract: This paper first introduces the concept, architecture, characteristics, key technologies and application fields of wireless sensor networks, especially in the application of environmental monitoring. Secondly, several typical routing protocols of wireless sensor networks are compared and Finally, on the basis of LEACH protocol, aiming at the problem that the cluster head is not uniform in the LEACH protocol and the number of nodes in the cluster is not reasonable, a new method is proposed, which is based on the demand of the environment. The algorithm of wireless sensor network based on genetic simulated annealing algorithm is used in environmental monitoring. The algorithm is used to optimize the selection of cluster head by genetic simulated annealing algorithm, and the optimal clustering of the network is made, so that the cluster head is distributed uniformly and the number of members is reasonable, Thus ensuring the network node energy load balance, extend network life.

Key words: Routing protocol; LEACH; genetic algorithm; simulated annealing algorithm

1. Introduction

The simulated annealing algorithm [50] is an effective global optimization algorithm, first proposed by the Metropolis et al. In 1953 according to the annealing principle. Solid annealing process is: the solid heated to a high enough to make it into a liquid, in the process, the solid particles with the temperature rise into a disorder, the internal energy increases, this process is called melting. Slowly cooling, the particles become more orderly, when the temperature dropped to the crystallization temperature, the liquid solidified into a solid crystal, the internal energy can be reduced to a minimum, this process is called annealing. In 1983, Kirkpatrick et al. Succeeded in applying it to combinatorial optimization problems [2].

2. basic idea of simulated annealing algorithm

The basic idea of the simulated annealing algorithm is to use the annealing process of the metal solid to simulate the optimization process of the optimization problem. When the metal solid reaches the minimum energy state, the objective function of the optimization problem also reaches the global optimal value accordingly [3]. The specific process described below [3]:

Step1: Determine the initial temperature t_0, generate the initial solution x, $k = 0$;

Step2: generate new solutions from the current solution $x' = generate(x)$;

Step3: If so, then; keep the current state unchanged;

Step4: If the current state $\exp(-(f(x') - f(x))/t_k) \geq random(0,1)$ does not meet the sampling stability criteria $x = x'$, go to Step2; otherwise go to Step5.

Step5: cool down, $t_{k+1} = update(t_k)$

Step6: If the algorithm does not meet the termination conditions, turn Step2; termination conditions are usually taken as a number of new solutions are not accepted when the termination of the algorithm;

Step7: Output algorithm search results.

3. Design of Simulated Annealing Algorithm

Simulated annealing algorithm is widely used, the design of the parameters will determine its optimal performance. However, the choice of simulated annealing algorithm parameters is still a difficult problem, usually only based on a certain heuristic criteria and with the nature of the problem or a lot of experiments to choose. Parameter design problems encountered are:

(1) Initial temperature T_0 setting

The initial temperature setting is one of the important factors that affect the global search performance of simulated annealing algorithm. The greater the likelihood of searching the global optimal solution, but it may lead to too long calculation time, which will affect the computational efficiency and make the simulated annealing algorithm lose its feasibility. On the other hand, the calculation time can be saved, but the global search performance May be affected. So the selection must be careful [2][4][5][7].

(2) temperature update function selection

In the simulated annealing algorithm, the temperature update has a great influence on the algorithm. If the temperature drops too fast, it may lose extreme points; temperature drop too slow, the convergence rate of the algorithm is greatly reduced. At present, many scholars have proposed a variety of temperature update programs to achieve the purpose of improving the computational efficiency and applicability of the simulated annealing algorithm[2][3][4][7].

① $T(k) = T_0 / \ln(1+k)$, the classic way of annealing, this method is characterized by a very slow temperature drop, therefore, the algorithm is relatively low efficiency.

② $T(k+1) = \alpha \times T(k)$, which is the number of cooling, is a slightly less than 1 constant. This attenuation function is Kirkpatrick et al first proposed, generally take 0.5 ~ 0.99.

③ $T(k) = T_0 / (1+ak)$, rapid annealing method, the way is characterized in the high temperature zone, the temperature drop faster, slow down in the low temperature area.

4. Improvement of LEACH Protocol Based on Genetic Simulated Annealing Algorithm

In this paper, the genetic and simulated annealing hybrid algorithm is proposed by inserting the simulated annealing algorithm into the main loop of the genetic algorithm to form a hybrid algorithm. The whole process of the algorithm consists of two parts: first through the genetic algorithm to evolve a group of solutions, and then use the simulated annealing algorithm to further optimize the individual gene adjustment. The run process is iterated until a certain termination condition is met. In order to improve the deficiency of LEACH protocol, this paper proposes a new clustering algorithm based on genetic simulated annealing algorithm, which is called CGSAA (Clustering based on Genetic Simulated Annealing Algorithm). The algorithm combines the fast global search performance of genetic algorithm and the local search efficiency of

the simulated annealing algorithm. By optimizing the parameters such as the residual energy and geographical position of the node, the cluster selection is optimized and the network is optimized. The distribution of nodes with uniform distribution, low energy and poor location becomes the possibility of cluster head, and the number of members is reasonable, so as to ensure the balance of energy load of network nodes and prolong the network life.

CGSAA and LEACH protocol, the operation is divided into rounds, each round contains the establishment and stable operation of the two stages. The base station broadcasts the message to the whole network, and requests each node to inform its own detailed information. After each node receives the message, it sends the message to the base station to report its own position and the remaining energy. Then the base station adopts genetic simulated annealing Algorithm for optimal clustering. Specific "round" operation process shown in Figure 1. In the subsequent rounds, the choice of the cluster head is optimized by considering the residual energy and geographical location parameters of the candidate nodes, thus effectively reducing the possibility that the nodes with energy and poor location are selected as cluster heads, further ensuring the network Equilibrium of energy load in inner nodes.

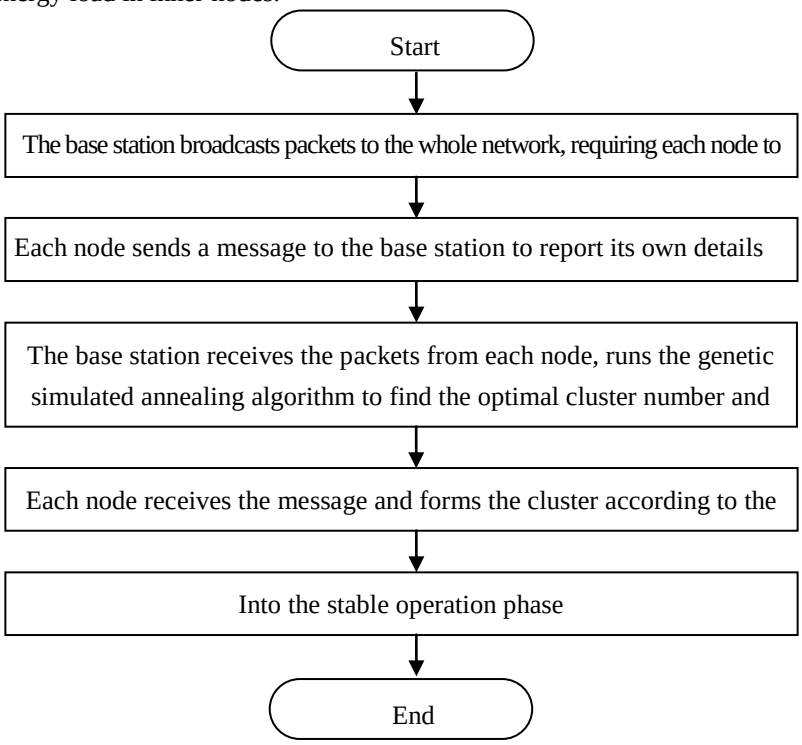

Figure 1 "round" operation flow

In the clustering process, we use genetic simulated annealing algorithm to get the optimal cluster classification.

(1) coding design

Coding of the nature of different problems and their solutions is one of the keys to solving the problem by genetic algorithm. In this algorithm, the encoding method uses binary code, which is mainly for the following considerations: First, coding, decoding operation is simple and easy; Second, cross, mutation and other genetic operations easy to achieve; there is easy to use the model theorem on the algorithm theoretical analysis. Assume that there are N nodes in the wireless sensor network, and K is the number of predefined clusters. The chromosome consists of n genes: $R_j = \{a_{1j} a_{2j} ... a_{ij} ... a_{Kj}\}$ j = 1,2, ..., popsize, popsizefor the

initial population size.

(2) fitness function design

In order to optimize the selection of cluster head and optimize the clustering of the network, the cluster head is distributed uniformly and the number of members is reasonable. Therefore, the residual energy and the position information of the node are considered synthetically in the fitness function design of genetic algorithm, Propose a fitness function as in equation (1-4).

$$f = \alpha \times d + \beta \times e \quad (1)$$

$$d = \max_{j=1,2,\ldots,K} \left(\sum_{\forall n_i \in C_j} d(n_i, CH_j) / |C_j| \right) \quad (2)$$

$$e = \sum_{i=1}^{N} E(n_i) / \sum_{j=1}^{K} E(CH_j) \quad (3)$$

$$d(n_i, CH_j) = \min_{\forall j=1,2,\ldots,K} \{ d(n_i, CH_j) \} \quad (4)$$

J = 1, 2, ..., K, that the total number of nodes within the cluster to the cluster head of the maximum average distance, said the total number of nodes within the cluster, that when the round of the total number of nodes, The initial energy of all nodes and the ratio of the sum energy of all candidate clusters, and the weighting coefficients of the average distance and residual energy in the cluster, respectively. Equation (4) is used to determine which cluster the node should join. The fitness function takes into account the residual energy and geographical location information of the nodes, which provides a guarantee basis for the optimal selection and uniform clustering of the cluster head.

(3) Select the operator

The choice of natural law that embodies the survival of the fittest is to improve the average fitness of the group by copying the individuals with high fitness values to the next generation. Its purpose is to select the progeny of the progeny from the group, to avoid gene loss, improve the global convergence and computational efficiency. Standard genetic algorithm is usually used in roulette selection method, but because of the larger choice of the method error, so this article uses the ranking and the best combination of individual preservation method of selection. The so-called ranking selection is based on the calculated fitness value of each individual to sort the individual in the group, and then assign the predetermined probability to the individual as the probability of their choice. In order to make the individuals with the highest fitness in the group not replicate directly to the next generation, the best individual preservation strategy evolution model [8] was used to carry out the survival fit operation, that is, the individuals with the highest fitness in the current group did not participate in the genetic Operation, but instead use it to replace the generation of the group after the genetic operation produced by the lowest degree of adaptation of the individual.

(4) crossover operator

The new excellent individuals are produced by the cross operation of two chromosomes. Crossover operator is the most important operation in genetic operation. In the process of crossover, the gene pattern of excellent individuals can be propagated rapidly and spread in the population, so that other individuals in the population can evolve in the direction of optimal solution. The algorithm uses two-point crossover to produce

offspring. If the parental chromosomes are 0101001 and 0100110, the cross positions are 3 and 6, then the progeny are 0100111 and 0101000. The choice of crossover probability is generally between 0.4 and 0.9.

(5) mutation operator

The purpose of the mutation operation is to maintain the diversity of the population and to avoid the local optimization of the solution. The algorithm uses a uniform variation strategy. Uniform variation refers to replacing the original gene values at each locus in a body coding string with a smaller probability, respectively, with a random number that is uniformly distributed within a certain range.

(6) replication strategy based on Metropolis criterion

After the above-mentioned selection of replication, crossover, mutation operation, the group obtained as the initial group, and then use the Metropolis criterion based on the replication strategy to generate the next generation of groups. The replication strategy based on Metropolis criteria can be divided into two steps [9]:

5. Concluding remarks

In this chapter, the genetic algorithm and the simulated annealing algorithm are introduced in detail, and the genetic algorithm is used to simulate the annealing algorithm to improve the cluster distribution in the LEACH protocol, and the number of nodes in the cluster is not reasonable. , The adaptive function of node energy and position information is designed, and the genetic simulation annealing algorithm is used to optimize the cluster head selection and optimize the clustering to achieve the purpose of saving energy. Finally, the improved algorithm is applied to the actual environment monitoring The results show that the improved algorithm is better than LEACH energy saving, basically achieve the desired effect.

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