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A Trust Information Search Model Based on Simulated Annealing in P2P Network

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Abstract: Trust information search algorithm is one of the most important components of P2P trust model. Considering the large number of nodes and the wide range of information each node contains in P2P network, efficient search algorithm can improve the network efficiency and attract more users to join P2P network. Moreover, efficient search algorithm can also let each node in the network know the current state of the network in time. This study designs an SABS (Simulated Annealing Based Search) model based on Simulated Annealing (SA) to search the trust information in P2P network. Simulation results show that this model can obtain the optimal path and the shortest distance of the network with appropriate parameter values.

Key words: P2P network, simulated annealing, trust information, search algorithm

INTRODUCTION

In P2P network, there are a large number of nodes joining and withdrawing from the network at any time. This phenomenon makes P2P network as a dynamics network and also makes learning about each node's information in time become a challenging work. In order to realize the safe, healthy and effective running of P2P network, the construction of trust model based on the information of each node is required. The key issue of constructing the trust model is how to calculate the trust values and the prerequisite for calculating the trust values is obtaining enough trust information, that is the search of trust information. The quality of trust information search algorithm affects the performance of the whole model directly and also affects the accuracy of the trust assessment directly. As a result, designing an effective trust information search model is imperative.

In real life, there are a large number of combinatorial optimization problems, mainly reflected in the scope of computer science and image processing, etc. Simulated Annealing (SA) is an optimization algorithm for solving large-scale combinatorial optimization problems with good performance (Ingber, 1993). It is a general probabilistic algorithm for finding the optimal solution of a problem in a big search space. Compared with the previous optimization algorithms, this algorithm has the advantages of simple description, flexible usage, wide application, high operating efficiency and less affected by the initial conditions, etc(Velis and Ulrych, 1996). In this study, Simulated Annealing is used in P2P network to search each node's trust information.

PROPOSED MODEL

In our proposed model, Simulated Annealing is applied into P2P network to reach the purposes of minimum information search cost and optimal search path.

There are a large amount of nodes in P2P network, where the distances between the two nodes are usually not the same. In order to study the relationships of the nodes, the positions of the nodes in the real network can be abstracted and mapped to three-dimensional coordinate system (Lua *et al*., 2005). For example, there are 4 nodes A, B, C and D in a P2P network, their coordinates are A(1,2,3), B(2,1.6,3.7), C(3,2.5,5.4) and D(4,0.8,6.6) respectively which positions in the coordinate system are shown in Fig. 1. Not only the relative positions of nodes can be seen from Fig. 1, but also the distances between them can be calculated. When the scale of the network is continually expanding, the similar abstraction and analysis can be done.

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Because of the significant dynamics in P2P network, nodes are joining or leaving the network constantly. The updating of the information in the routing table of current nodes is needed at any time (Buford and Yu, 2010). This makes designing a search algorithm which is capable of reaching all the nodes in the network imperative. Through introducing Simulated Annealing into P2P network, each node is regarded as every state in the Annealing process, the distance between two nodes is regarded as energy difference of two states and the purposes of searching each node and the shortest of overall path are reached.

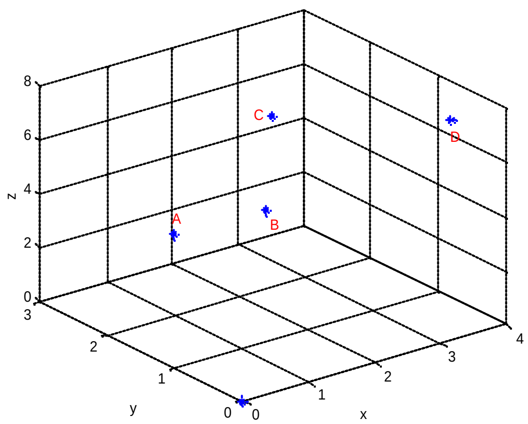

Fig. 1: Positions of nodes A, B, C and D in the coordinate system

The algorithm flow of our proposed model is shown in Fig. 2.

As shown in Fig. 2, the design steps of our model called SABS model are as follows.

- **Node mapping in P2P network:** All the nodes are mapped in P2P network into three-dimensional coordinate system and the specific coordinate value of each node is input into the model. For the convenience of expressing the final output results, taking the first dimension coordinate value as the node number (shaped like the integers 1, 2, 3,…), the output path is expressed with the number
- **Solution space and initial solution:** The solution space S of this model are all the loops visiting each node in P2P network and also are the sets of the permutations of all nodes (totally n). The solution space S can be expressed as the sets of all the permutations of {1, 2,…, n}, that is $S = \{p_1, p_2,\ldots, p_n\} \mid (p_1, p_2,\ldots, p_n)$ is the permuations of {1, 2,…, n} in which each permutation s_i denotes one path visiting all the nodes, $p_i = j$ denotes the ith visit to node j. The initial solution s_0 is a permutation of {1, 2,…, n} generated by a random function
- **Objective function:** The objective function of this model is the total path length visiting all nodes which is also called cost function:

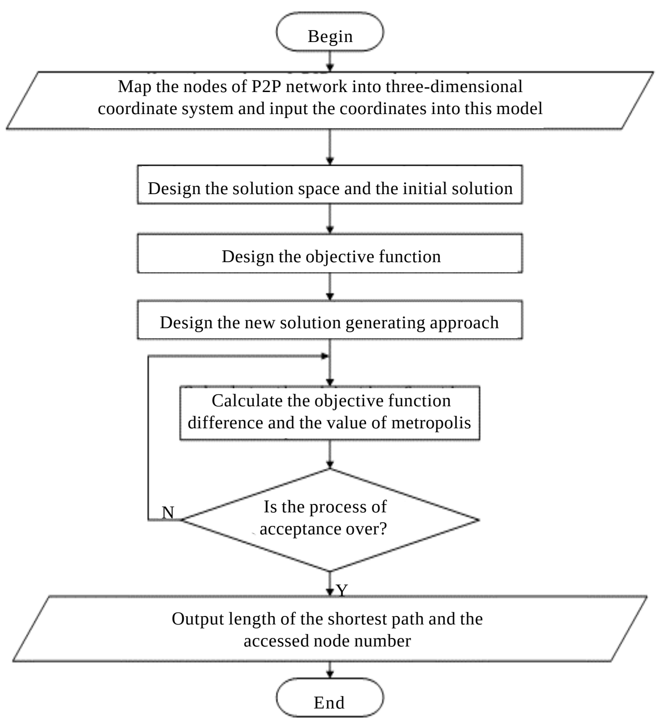

Fig. 2: Algorithm flow

$$C(p_1, p_2, ..., p_n) = \sum_{i=1}^{n-1} d(p_i, p_{i+1}) + d(p_1, p_n)$$

This model calculates the minimum of objective function C (p_1, p_2,..., p_n) through Simulated Annealing and accordingly, S = (p_1*, p_{2}*,..., p_n*) is the optimal solution of this model.

- **Generating approach of the new solution:** The generating of the new solution is very important for the solution of the model. It can be generated by using the following two approaches respectively or alternately

The first approach is the two-transform method: selecting the number u and number v randomly (supposing u<v<n), exchanging the accessing order of u and v.

The second approach is the three-transform method: Selecting number u, number v and number w randomly (supposing u≤v≤n), inserting the path between u and v into the rear of w to visit.

- **Objective function difference:** The difference of the solution before transforming and the objective function after transforming is $\Delta C' = C(s_i')-C(s_i)$
- **Calculating acceptance probability:** The acceptance probability is calculated using the difference of the objective function of the new solution and the current function, that is:

$$P = \begin{cases} \exp(-\Delta' / T), \Delta C' > 0 \\ 1, \Delta C' < 0 \end{cases}$$

SIMULATION EXPERIMENTS

This section carries out simulation experiments on SABS model. For the purpose of knowing the capability of this model and the influences of each parameter on this model comprehensively, in the P2P network, there are 200 nodes. The simulation experiments are based on MATLAB 7.0.

In the simulation experiments, T_0 denotes the initial value, T_f denotes the final value, α denotes the parameter of attenuation function and L_k denotes the length of Markov chain (Susitaival *et al*., 2006; Cooper *et al*., 2009). The algorithm of SABS model are used to calculate the shortest distance visiting all the nodes in P2P network under different parameters and the corresponding path is expressed. At the same time, the simulation experiments also analyze the influence of each parameter (T_0, T_f, α and L_k) on model performance.

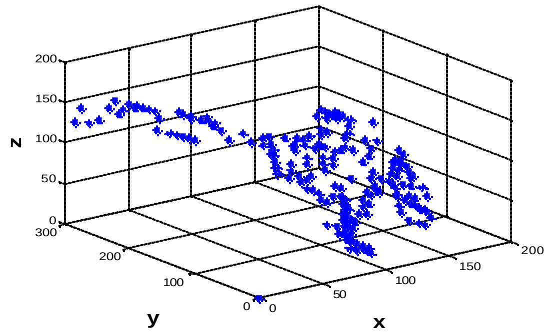

Fig. 3: Position of each node in the coordinate system in P2P network

Table 1: Simulation parameters of experiment 1

Simulation number	α	T_0	T_f	L_k
1	0.98	100	0.01	15000
2	0.75	100	0.01	15000
3	0.65	100	0.01	15000

Table 2: Three simulation results

Simulation number	Shortest distance	Program running times
1	2177.1	10
2	2386.3	10
3	2484.9	10

Table 3: Simulation parameters of experiment 2

Simulation number	α	T_0	T_f	L_k
1	0.98	99	0.02	20000
2	0.98	90	3.00	20000
3	0.98	80	4.00	20000

Mapping them to three-dimensional coordinate system, the position of each node in the coordinate system is shown in Fig. 3.

Simulation experiment on parameter α of attenuation function: There are three simulation experiments in different α values. The simulation parameters of experiment are shown in Table 1.

Substituting each parameter into the model, the calculated shortest distances are shown in Table 2.

As shown in Table 2, after running the program several times, the results comparison is shown in Fig. 4.

As shown in Fig. 4, when α equals 0.98, 0.75 and 0.65, the shortest paths are 2177.1, 2386.3 and 2484.9, respectively.

Simulation experiment on initial value t_0 and final value T_f: The simulation parameters of experiment 2 are shown in Table 3.

Substituting each parameter into the model, the calculated shortest distances are shown in Table 4.

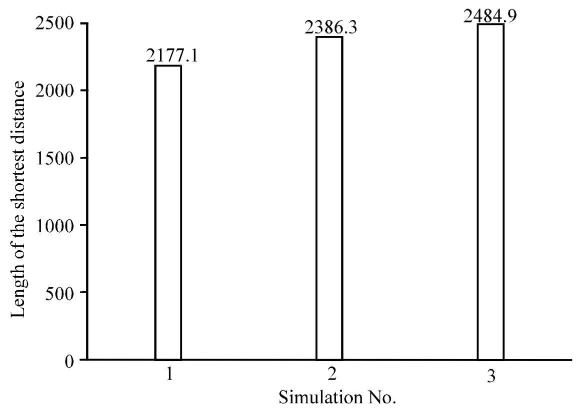

Fig. 4: Results comparison

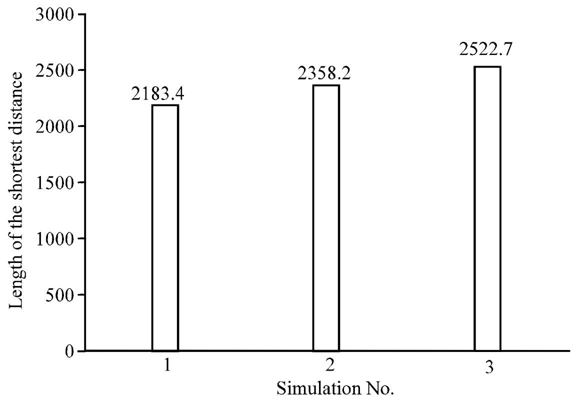

Fig. 5: Results comparison of experiment 2

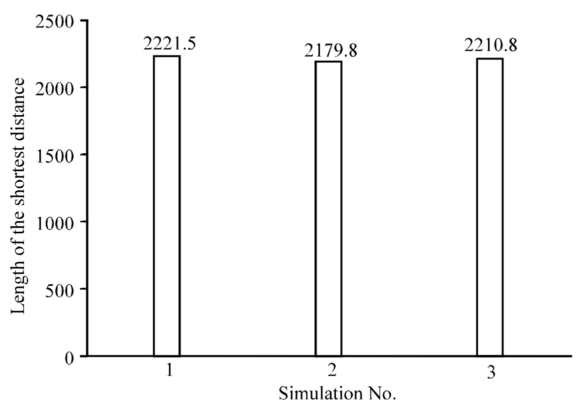

Fig. 6: Results comparison of experiment 3

As shown in Table 4, after running the program several times, the results comparison is shown in Fig. 5.

As is shown in Fig. 5, choosing three groups of T_0 and T_f, the shortest distance visiting all the nodes in P2P network are 2183.4, 2358.2 and 2522.7, respectively.

Table 4: Three simulation results of experiment 2

Simulation number	Shortest distance	Program running times
1	2183.4	10
2	2358.2	10
3	2522.7	10

Table 5: Simulation parameters of experiment 3

Simulation number	α	T_0	T_f	L_k
1	0.97	100	0.01	10000
2	0.97	100	0.01	15000
3	0.97	100	0.01	20000

Table 6: Three simulation results of experiment 3

Simulation number	Shortest distance	Program running times
1	2221.5	10
2	2179.8	10
3	2210.8	10

Simulation experiment on the length of Markov chain L_k: The simulation parameters of experiment 3 are shown in Table 5.

Substituting each parameter into the model, the calculated shortest distances are shown in Table 6.

As shown in Table 6, after running the program several times, the results comparison is shown in Fig. 6. As is shown in Fig. 6, choosing three groups of L_k, the shortest distances visiting all the nodes in P2P network are 2221.5, 2179.8 and 2210.8 respectively.

This section carries out a group of simulation experiments on the designed SABS model. As can be seen from the experimental results that using this model, the shortest path visiting all the nodes in P2P network can be searched and the length of the shortest distance can be calculated. Moreover, adjusting the values of the parameters in the algorithm (α, T_0, T_f and L_k), the shortest path and the optimal path are not the same. Specifically summarized as follows.

- Through the simulation experiments in P2P networks, SABS model can be applied into actual P2P network. This algorithm has the advantages of efficiency, robustness, flexibility and generic, etc. What's more, this algorithm has great reliability and practical value
- In actual P2P network, when searching the trust information of each node or updating the routing table of each node, the path corresponding to the shortest distance calculated by SABS model can be chosen and the first node of this path can be used as the starting node to carry out the corresponding operations

CONCLUSION

This study introduces Simulated Annealing in P2P network and a SABS model is designed. The actual P2P network is abstracted and is mapped to three-dimensional coordinate system. Simulated Annealing is used to solve the shortest path visiting all the nodes in the network and the corresponding optimal path is found. Finally, the model is tested with simulation experiments and the parameters affecting the experimental results are classified and discussed. Experimental data shows that SABS model is effective. The designed and constructed SABS model uses the advantages of efficiency and utility of Simulated Annealing which is capable of searching or updating the node information in P2P networks of different sizes. The practical value of this model is high.

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