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Routing Optimization Based on Artificial Fish Swarm Algorithm

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Abstract
For multi-objective optimization in the QoS routing, this paper combines the artificial fish swarm algorithm and ant colony algorithm and tabu search algorithm, proposes a new improved algorithm, and delves into the application of solving the QoS routing. One main work in this paper is to put forward a mixed algorithm integrating artificial fish swarm and ant colony. Firstly, we randomly generate a network topology by the improved Salama algorithm. Secondly, we find out many feasible paths that satisfies constraint conditions by the parallel search feature of ant colony algorithm. Thirdly, we create the alternative path set. Lastly, we use artificial fish swarm algorithm to solve the optimum multicast tree in the created alternative path set through the foraging, bunching, tailgating, and other behaviors. The other main work in this paper is to put forward a mixed algorithm integrating the artificial fish swarm and the tabu search. Firstly, we divide the region needs to be searched into several sub regions and rapidly solve suboptimum solutions in each sub region with the fast convergence capacity. Secondly, we solve suboptimum solutions in each sub region by taking suboptimum solutions as initial solutions in the tabu search algorithm. Thirdly and lastly, we sort the optimal solutions in each sub region with the bubble sort and thus solve the global optimal solution.
Key words: QOS ROUTING, ROUTING OPTIMIZATION, ARTIFICIAL FISH SWARM, TABU SEARCH ALGORITHM, SUBOPTIMUM SOLUTION

1. Introduction

With the expanding network scale and application services, especially the emergence of multimedia application technology, as well as the demand of interactive application services, the Quality of Service (QoS) has set a higher demand on the network. Due to the rapid development of network and widespread use of distributed multimedia, QoS with higher standard becomes more and more important. The first issue needs to be addressed in QoS routing is how to determine the standard for path selection. QoS can be described by using different metrics and indexes, such as cost, jitter, loss rate, delay, and bandwidth. These QoS indexes can measure different demand features of the services, and elaborate the corresponding network status. In fact, QoS issue is to delve into the management and control of resources in the network. For studies on QoS routing, experts and scholars presented many different algorithms, and made the analysis and classification from different points of view. Different routing models, routing strategies, and hypotheses on network status information, may contribute to different classifications of the routing algorithm. For example, in accordance with the number of target parameters require to be optimized, QoS routing can be divided into single constraint QoS routing and multi constraint QoS routing. The idea that single constraint QoS routing are relatively easier to solve the multi constraint QoS routing has been proved of a NP-complete issue [2], and no superior solution has been put forward at present. Based on the routing strategies selected, QoS can also be divided unicast routing and multicast routing [3]. The unicast routing means that the search from

Unicast routing refers to the path established with the search from a given source node to the destination node that can meet the constraints. Multicast path generally refers that from a given source node to the destination node set, searching the multicast tree that can meet the restraints. Both routes can be associated, and in most modes, multicast routing can be regarded as the generalization of unicast routing. With the rapid development of computer technology, the QoS issue of Internet has gradually become one of the attractive and important core research areas in the internet research in the world, and gradually become a popular topic in the Internet research today. Therefore, studying QoS issue of the Internet has relatively important significance on the Internet technology applications, development, and research in the future [4]. Due to the complexity of the Internet itself, it has caused obstacles in the study of Internet QoS. For the study of QoS routing, it is relatively new, and our present the study of QoS routing issue is still at the primary stage at present, the research focuses on the range of applications includes two elements: 1. Unicast routing. Under normal circumstances, QoS unicast routing study mainly contains four kinds of the most basic QoS routing issues [5]: Link single constraint issue; b. Link single objective optimization issue; c. Path single constraint issue; d. Path single objective optimization issue. These four most basic issues can be solved by the traditional Dijkstra algorithm or Bellman_Ford algorithms. Bionic intelligent algorithms are mainly: Genetic algorithms, particle swarm optimization, ant colony algorithm, simulated annealing algorithm, artificial fish swarm algorithm, evolutionary algorithms and new algorithms of improved algorithm derived from these algorithms or combined algorithms obtained from several algorithms. Document [6] proposed an improved ant colony algorithm, which has generally seemed effective and has greatly improved in performance than the basic ant colony algorithm. But there are constraints of this upgrade, the algorithm does not fundamentally solve the shortcoming of susceptibility to the lesser range optimization. Document [7] proposed a method based on artificial fish, while the number of iterations in the design of the method is too many. Document [8] improves the optimization effect by mixing algorithm, however, this method cannot effectively improve the performance.

This paper intends to draw on the existing achievements, to combine the artificial fish swarm algorithm and ant colony algorithm and tabu search algorithm, to propose new improved algorithm, and explore its application in solving QoS routing issues.

2. Mathematical Model of QoS routing issue

In order to facilitate the understanding of QoS routing issue, here we only discuss the network models with three QoS constraint conditions of delay, bandwidth, and cost, as shown in Figure 1. Figure There are 20 nodes and 37 edges in the figure. Wherein the source node is node 1, node 20 is the destination node, the network structure characteristic of each side of the model is represented by a triple (D, B, C) group, where, D represents the delay, B represents the bandwidth, C represents the cost.

With a undirected weighted graph G <V, E> to represent the network, in which $V=\{V_1,V_2,\cdots,V_N\}$ represents the network node set, equivalent of network routers, switches, hubs and other network node apparatus. N represents the number of nodes, $E=\{E_1,E_2,\cdots,E_M\}$, E represents the link set, M represents the number of network links, and each link $E_i \in E$ contains three properties, with the triple representation (Bandwidth, Delay, and Cost) respectively to indicate bandwidth, latency and cost of the link. . For any link $E_i \in E$ defines the following three metrics function, delay function Delay (e): $E \rightarrow R+$, Bandwidth function BandWidth (e): $E \rightarrow R+$, cost function: Cost (e): $E \rightarrow R+$.

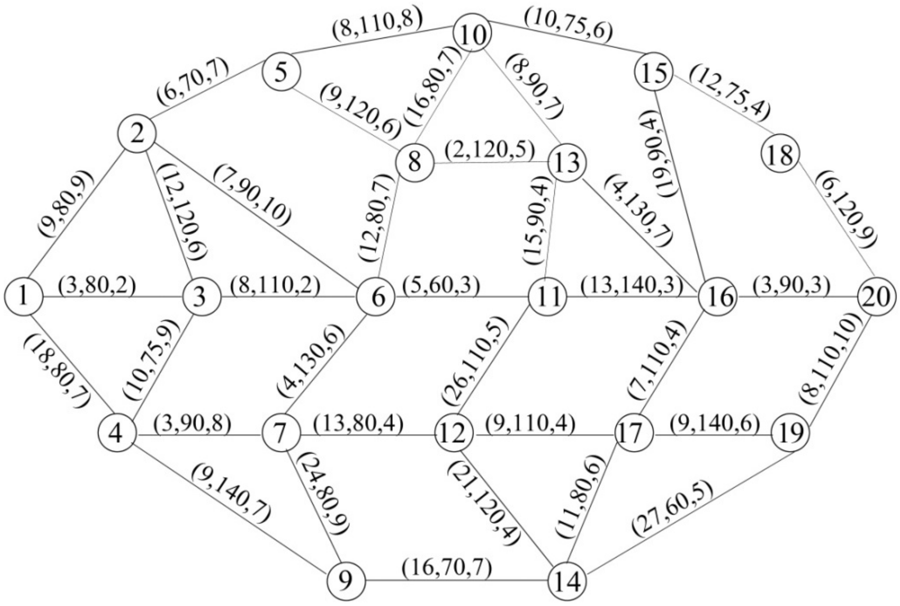


Figure 1. Network Structure

For a given initial node $s\in V$, the destination nod t, $t\in\{V-\{S\}\}, P(s,t)$ is a path between s and t, with the following relationship:

$$Delay(p(s,t))=\sum Delay(e).e\in p(s,\quad (1)$$

$$Cost(p(s,t))=\sum Cost(e).e\in p(s,t) \quad (2)$$

$$BandWidth(p(s,t))=\min\{BandWidth(e)|e\in p(s,t)\} \quad (3)$$

QoS unicast routing is to find a path from the initial node s to the destination node t $p(s,t)$ to meet the following constraints:

Delay constraints: $Delay(p(s,t))\le D$ (1)

Broadband constraint: $BandWidth(p(s,t))\ge B$ (2)

Cost constraint: In all the paths that meet the condition of(1) and (2), $Cost(p(s,t))$ is the minimum.

$$MinCost(p(s,t))$$

$$s.t.Delay(p(s,t))\le D$$

$$BandWidth(p(s,t))\ge B$$

QoS multicast routing issue usually contains link cost, delay, bandwidth, delay jitter, packet loss and other QoS constraints. However, in order to simplify the model, this paper only considers the cost of multicast tree, latency and bandwidth constraints. With T(s,M) represents the multicast tree. s is the initial node of multicast, M is the set of nodes of multicast transmission, $d(d\in M)$ is the destination node collection of multicast. The path from the initial node s to the destination node $d(d\in M)$ is identified by $P_T(s,d)$, then the total cost function of multicast tree is:

$$Cost(T(s,M))=\sum_{e\in T(s,M)} Cost(e)$$

The delay of multicast tree on the path $P_T(s,d)$ is:

$$Delay(P_T(s,d))=\sum_{e\in P_T(s,d)} Delay(e)$$

The minimum bandwidth on the multicast tree path $P_T(s,d)$ is:

$$Bandwith(P_T(s,d))=\min\{Bandwidth(e)|e\in P_T(s,d)\}$$

QoS multicast routing issue is essentially the issue of minimum cost of multicast tree in the bandwidth and latency constraints. Its mathematical model is as follows:

$$Min \quad Cost(T(s,M))$$

$$s.t. \quad Delay(P_T(s,d))\le \Delta_d, \forall d\in M$$

$$Bandwidth(P_T(s,d))\ge B_d, \forall d\in M$$

3. Hybrid Algorithm for Solving QoS Routing Issues with Ant Colony Algorithm Based on Artificial Fish

Algorithm Ideas:

1. Apply the improved network topology Salama for random generation algorithm, to generate a random network topology; use K-means clustering to control node density distribution when generating the topology map, which makes the network topology connectivity and uniformity better generated , the resulting network topology data is rich, including: the

cost of the link, cost of delay, bandwidth, nodes, delay, delay jitter, packet loss rate; for link delay, assuming it is equal to node distance by three two-thirds of the speed of light, so that it will be more realistic.

2. According to the link and path QoS constraints, delete the duplicate nodes that do not satisfy the bandwidth constraint;

3. Apply ant colony algorithm parallel search features to identify a large number of feasible paths that meet the constraints, so as to create an alternative path set, intensify QoS constraints on path selection, weaken the impact of costs on the path chosen, which is reflected by the pheromone and the penalty coefficient;

4. Apply the artificial fish swarm algorithm in the created alternative path centralization, through the implementation of foraging, clusters, rear-end and other acts to solve the optimal multicast tree.

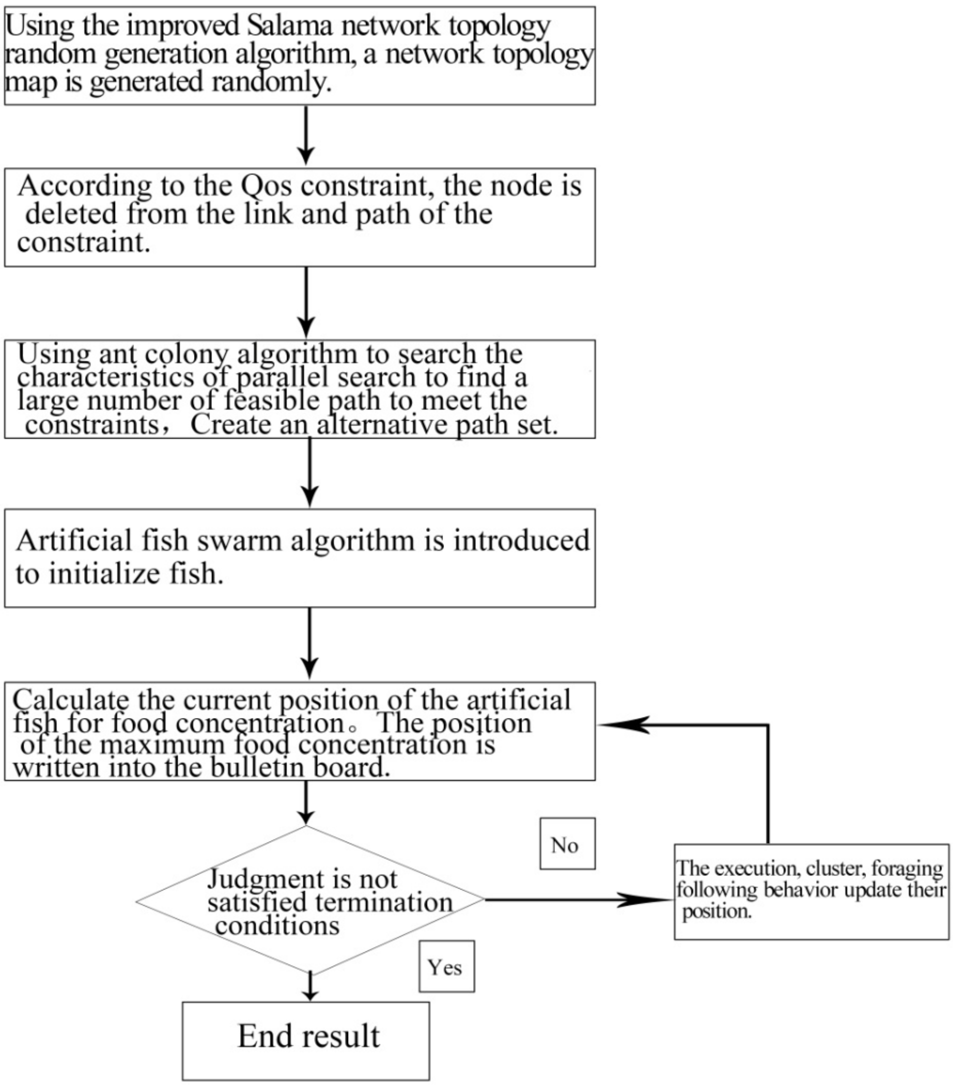


Figure 2. Program Flow Chart

The generation of simulated network topology adopts an improved Salama random generation algorithm to generate a network topology map. The basic idea is: N network nodes randomly generated within a given square area, according to the order of the horizontal re-ascending node numbers for each, with the K-means clustering to control the density distribution of nodes, use α , β two network characteristic parameters to control network in the long and short sides, distance from the network nodes, network nodes adopting Euclidean distance, the two nodes in accordance with a certain probability Pe to introduce cable, this probability is related to the distance between nodes, so that the distance between the edge is associated between the nodes. Probability Pe

According to the following equation:

$$P_c = \beta \exp \frac{-Dis(i,j)}{\alpha L_{\max}}$$

where the distance $Dis(i, j)$: $L_{\max}$ is the maximum distance between any two nodes, and α and β are the network characteristic function, when given during initialization, the greater the α is, the short side opposite long edge ratio; the larger the β is, the denser the edge. Adjusting α and β to make the network diagram of the remaining years more reasonable. If the node is not connected to the present, then randomly selects a node with its connection to ensure connectivity of the network. Link delay equal to node distance divided by two-thirds the speed of light, which is more in line with the actual situation. Network topology data thus generated is rich, including: link cost, delay, bandwidth, cost of nodes, delay, jitter, packet loss rate. Specific steps randomly generated network topology is as follows:

STEP 1 Enter the initial parameters, based on the input parameters, generating node, and then to the node in ascending sequence number, i = 0;

STEP 2 Extract two vertices randomly;

STEP 3 If these two vertices to identify different, and there is no connection between the two nodes, while less than the maximum specified in these two vertices of degree, the production side of the preceding equation, and assigned to the edge, otherwise return to STEP 2;

STEP 4 $i = i + 1$

STEP 5 If i is less than the specified number of sides to return to STEP 2, otherwise enter STEP 6;

STEP 6 If the resulting figure is a non-connected graph, then delete diagram and then return to STEP 1;

STEP 7 ends.

Figure 3 is a network topology randomly generated according to the above steps. Simulation hardware platform CPU2.4G, memory DDR 1G; the operating system is Windows XP, the programming software used is MATLAB7.0.

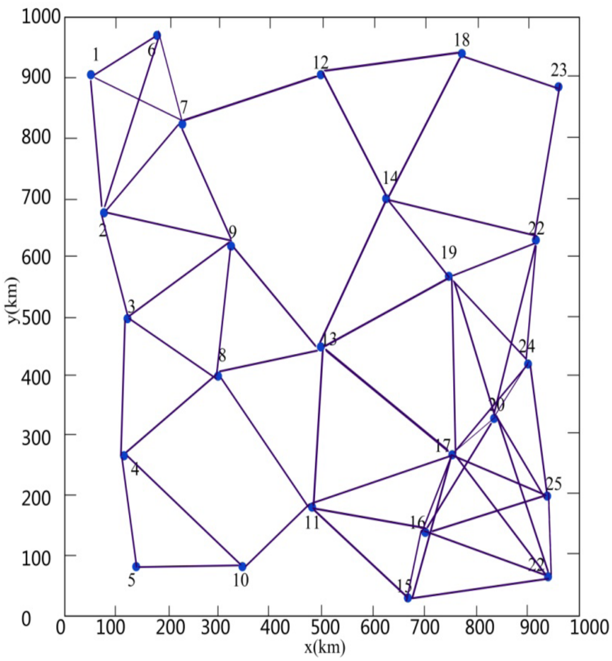


Figure 3. Network topology containing 25 nodes

As can be seen from Figure 4, when the improved algorithms is compared basic artificial fish swarm algorithm, the former 80 has obvious advantages, faster than the basic artificial fish swarm algorithm solving speed. And in the back, as a result it has reached the optimum, the difference is not great. Figure 5 is the improved artificial fish swarm algorithm obtained after the multicast tree. To further validate the algorithm, in this, we then randomly generate a network topology map contains 50 nodes, Figure 6, the initial node is [6], and the destination node is [45,48,49,50].

4. Artificial Fish and Tabu Search Algorithm Combined to Solve QoS Multicast Routing Issue

Although artificial fish swarm algorithm overcomes the negative impact brought by local extreme, having the ability to achieve global best, but this method is relatively difficult to obtain exact optimal solution. Though it has an advantage in some routing issue solving, it cannot meet the requirements of multicast QoS, only relatively easy to find the optimal solution domain, and the algorithm in terms of computational complexity and convergence also has larger defects.

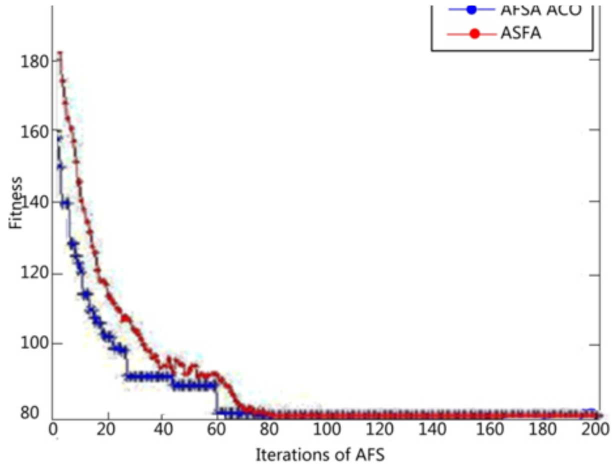


Figure 4. Simulation Diagram Obtained from the Improved Artificial Fish Swarm Algorithm

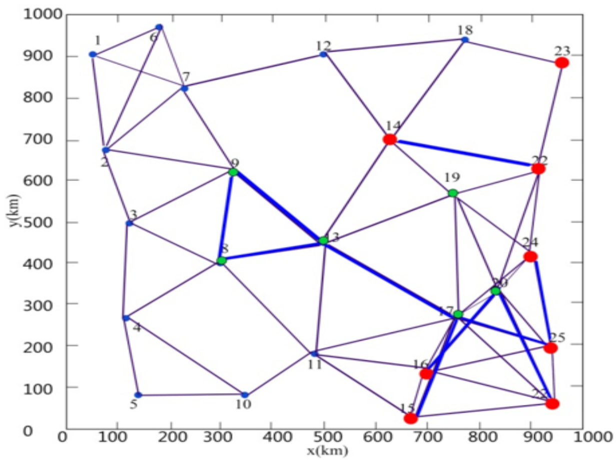


Figure 5. Multicast Tree Obtained from the Application of the Improved Artificial Fish Swarm Algorithm

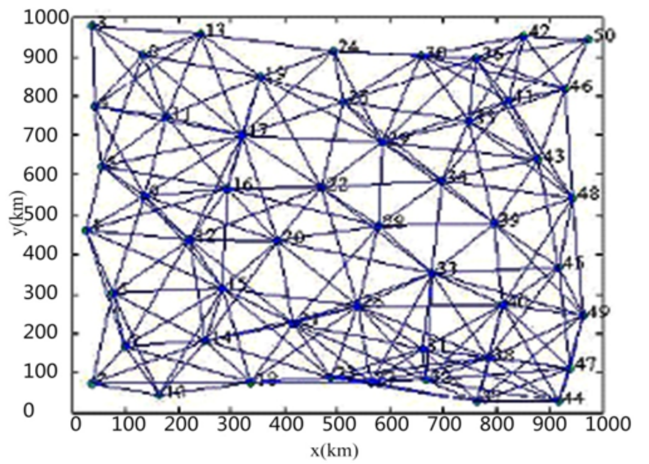


Figure 6. Network Topology Map with 50 Network Nodes

For these issues, this chapter introduced the partition search method and tabu search algorithm for improved artificial fish swarm algorithm, and apply them to solve the QoS multicast issue. Artificial fish algorithm is a simulation based on the behavior of fish random search optimization algorithm, generally each artificial fish optimizing a wide range of time, the exact solution is not available, only to find a more satisfactory solution domain. In order to solve this issue, we introduced the idea of zoning, which will divide the entire search area network nodes into several sub-regions, and each sub-area contains several network nodes. The experiment found that the improved algorithm which area size and solution accuracy has a direct relationship, in general, the smaller the area is, the higher the accuracy of the algorithm will be, but the time required is relatively longer; conversely, the lower the precision is, the shorter the time is used.

Therefore, based on the current size of the network number, the appropriate division of the network area shall be performed. Here, we will apply tabu search algorithm to combine with artificial fish swarm algorithm introduced to solve the QoS multicast routing issue. Firstly, number the area that has been divided, and then continue the introduction of artificial fish individuals in all regions, the use of artificial fish foraging behavior, swarming behavior and other acts of rear-end local search suboptimal solution to the artificial fish algorithm search local suboptimal solution with tabu search algorithm as the initial solution, and apply tabu search algorithm to search for local optima. Set up bulletin boards in all of the search area, and note the partial optimal solution region. Finally, the bubble sort algorithm of optimal local bulletin board is sorted, to arrive at the whole optimal solution. In order to test the performance recognition of the continuous action set above, we have done a lot of experiments.

(1) Algorithm Description

Firstly, introduce the following symbols for the artificial fish swarm algorithm, as shown in the following Table.

Symbol	Meaning
N	The number of fish in artificial fish (corresponding to the number of nodes in the network)
$X = (x_1, x_2, \cdots, x_n)$	Status artificial fish individuals, represents a set of n paths in the network
$x_i\ (i = 1, 2, \cdots n)$	For optimization of the variables, the corresponding to the optimal path in the network
$y = f(x)$	Artificial fish food concentration current location, y is the objective function, corresponding to the concentration in the network to link food costs and delays and. When the shorter the expense and delay, the greater the concentration of the food on the link.
$d_{ij} = \lVert x_i - x_j \rVert$	Artificial distance between individual fish, this parameter in the network can be defined as the distance between nodes, such as the distance between adjacent nodes is defined as 1
Visual	Sensing range of artificial fish, as defined in the network for the artificial fish can perceive neighbors.
Step	The length of artificial fish moving step, in step network routing issue it is defined as artificial fish can only move from one node to its neighbor nodes.
δ	Crowding factor, defined as the bandwidth where the fish on artificial path.
Number of trials	Number of attempts

The algorithm steps are as follows:

STEP1 Divide the network topology into several sub-region, and set up a bulletin board for each sub-region.

STEP2 Use fish algorithm for suboptimal solutions in selected sub-regions.

Specific steps are as follows:

1. In selected sub-regions (first when solving selected sub-region should be the area where the source node) initialization fish algorithm parameters $(N, Try\_number, \delta\ visual, step)$ and iterations $n_i = 0$.

2. Artificial fish random walks in the field of view, the current state is x_i, and it gets close to the food when spotting the food.

3. Feeding Action:

(a) Provided $m = 0$, the current status set to artificial fish is x_i;

(b) The implementation of $x_j = Random(N(x_j\ visual))$ to generate a new state,

(c) If $f(x_i) < f(x_j)$, the state of the artificial fish will be amended as follows:

$$x_i \leftarrow x_j + Random(step)(x_j - x_i)/\lVert x_j - x_i \rVert$$

Otherwise, if $m < Try\_number$, return to (b) for execution:

(d) Performing a random walk behavior further:

4. Clusters Action:

(a) Generate the set of its peers in its visual field of view of the $K = \{x_j \mid x_j, x_i \le visual\}(i, j = 1, 2, 3, \cdots n)$

(b) If K is a non-empty set, in accordance with the following formula its location can be found: $x_c = \sum x_j / n_j$, where n_j is the number of regional peers, namely $n_j \ge 1$;

(c) If $n_j / n < \delta(0 < \delta < 1)$, and at this time $f(x_i) < f(x_c)$, the artificial fish forward further to the center position $x_{incv} = x_i + Random(step)(x_C - x_i)/\lVert x_c - x_i \rVert$, else perform STEP2.

5. Rear-end Action:

(a) In the search range whether there is the best partners in the state "“x_{max}" , if no will to continue the implementation of STEP2, otherwise perform the next step;

6. Whether iterations are met, if not met, perform STEP2 in 2. to meet the output. STEP3. Perform STEP2 to suboptimal solutions to obtain the initial solution Tabu search algorithm, the optimal solution for local search. Specific steps are:

(1)Randomly generated initial solution x, and set parameter values taboo algorithm, set tabu list is empty.

(2)Taboo algorithm to judge the termination condition is satisfied. If you can meet, they can end the algorithm and to the region in search of the optimal solution to the output corresponding to the region of the bulletin board, at the same time, recorded in the bulletin board under the cumulative number of iterations performed the most ultimate bubble sort of basis. Otherwise proceed to the next step

(3)Take full advantage of the current solution neighborhood function of all or several of its neighbors produce solutions, and determine the number of candidate solutions from among them.

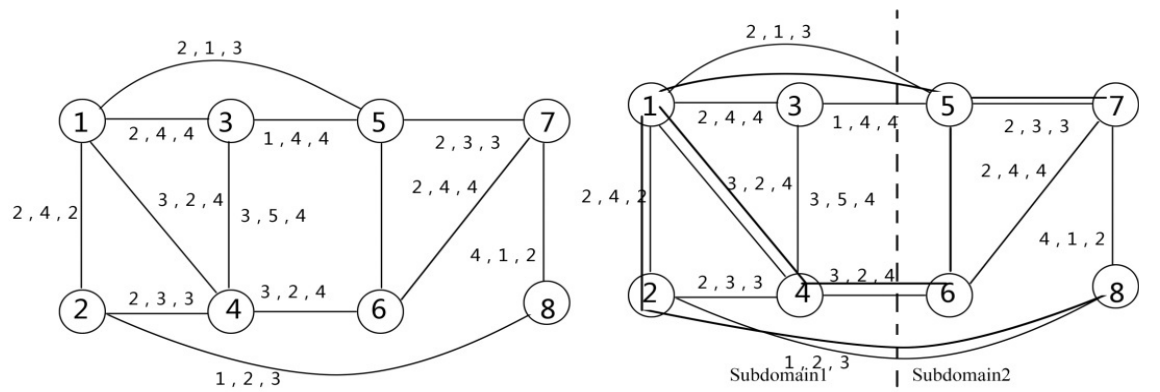
STEP4 The above destination node is not an area adjacent to the region as the next area of the source node, perform STEP2 and STEP3. If the region is the region where the ultimate destination nodes are, stop searching.

STEP5 If the search is ended, places the accumulated number of iterations of the regional bulletin board records as the basis for the optimal solution district recorded by the bubble sort, eventually forming a global optimal solution.

5. Numerical Simulation

The simulation is conducted in NS2 (Network Simulator Version 2). Virtual topology as used in Figure 7 (a). The network topology consists of eight nodes. Triples represent each path cost, delay and bandwidth of the three constraints. When the simulation to the network node 1 is the source node, the network node to the destination node is 6, 7, and 8. We propose to combine artificial fish tabu search algorithm (AFTA), particle swarm genetic algorithm (PGA) and genetic algorithms (GA) to solve the simulation, such as solving the routing results in Figure 7 (b) below. Here we compare their QoS satisfaction and optimal rate.

The simulation results show that satisfaction bandwidth and latency, bandwidth and latency constraints for QoS multicast routing issue, AFTA algorithm and PGA algorithm performance is better, but AFTA algorithm shows a higher convergence of the three algorithms speed. Generally speaking, after three algorithms in about 60 iterations later, with QoS constrained multicast user satisfaction can reach more than 95% from 8 and 9 can be seen in the time to achieve the same satisfaction, AFTA iterations of the algorithm used for less than the other two algorithms; and for the use of the same number of iterations, AFTA algorithm can achieve satisfaction higher than the other two algorithms, and in this chapter AFTA algorithm is faster.



(a) Network topology graph

(b) Simulation results route map

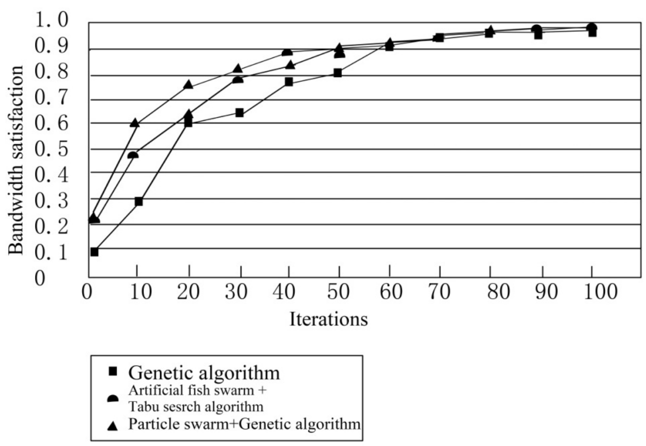


Figure 8. Three algorithms bandwidth satisfaction comparison

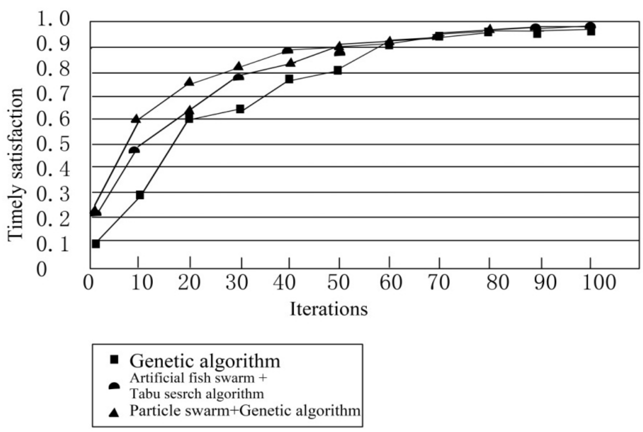


Figure 9. Three algorithms delay satisfaction comparison

6. Conclusion

This paper describes the background and research status of QoS routing issues, with the simple introduction of the ant colony algorithm, tabu search algorithm, the basic principles of artificial fish swarm algorithm, and several algorithms and their advantages and disadvantages. Artificial fish swarm algorithm is proposed as the improvement ideas, there are two main aspects: Firstly, the artificial fish swarm algorithm and ant colony algorithm combination, and secondly, the artificial fish swarm algorithm and tabu search algorithm combination, then combine the features of QoS routing issue, and apply both algorithms to solve the QoS routing issue. Adopt numerical simulation cases, and the results show that the improved algorithm for solving QoS routing issue has better performance than normal algorithm, better speed and efficiency than other algorithms.

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Mobile Healthcare System for Driver Based on Drowsy Detection Using EEG Signal Analysis

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