

The Research on QoS Routing Algorithm Based on Improved Optimization Sorting Ant Colony Algorithm

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Abstract. In ordering to resolve the slow convergence problem of ant colony algorithm in QoS routing, this paper presents a sort of ant colony algorithm which based on optimized sequence. In global pheromone updating, this algorithm weakens the influence of a single iteration solution and adopt a combination of the optimal solution within the scope of the iteration, which could make ant still choose the best path toward a particular direction when a poor solution occurs. At last, the simulation experiments proves that convergence rate of this improved ant colony algorithm works significantly faster, and stability has been greatly improved.

Introduction

With the rapid development of computer technology, people draw more attention to the demand for more complex and more specific networks environment. In recent years, multimedia services gradually become the popular service in market, and these applications have their own strict constraints in bandwidth, delay, packet loss rate. Therefore, how to provide a better QoS (Quality of Service, QoS) for network environment, it's an important guarantee for multimedia services.

The task of QoS routing is to find a path that could meet the bandwidth, delay and other restrictions in the network. Wang Z demonstrates that it is an NP-C problem[1] when the QoS routing contains at least two limitations. In the current network routing algorithm, ant colony algorithm in solving QoS routing problem has been a good application, but the problem of slow convergence rate and long convergence time still exists.

By the analysis of the ant colony algorithm, based on the optimization of sorting ant system, this paper proposes a new ant system named RRB-AS(Recent Rank-Based Version of Ant System). This algorithm improves the global update policy, weakens ant's single search result, so the route will maintain optimal in the range of a certain number of iterations. Even though the ant makes a inferior choices occasionally, the ant will go ahead at a reasonable trend.

Analysis of QoS routing constraint in network

In the usual analysis, we simplify the network as an undirected weighted graph. Let $G(V, E)$ represent a network[2], V represents a collection of nodes and E represents a set of links in the network[3], each edge represents a direct path between two nodes[4]. For a routing request, it is accepted if you can find a path with a small cost, while meeting the following four conditions by routing algorithm:

Delay constraint is shown in the formula(1):

$$\text{delay}(P) = \sum_{e \in P(E)} \text{delay}(e) + \sum_{n \in P(V)} \text{delay}(n) \quad (1)$$

$$\text{delay}(P) \leq D$$

Bandwidth constraint is shown in the formula(2):

$$\text{bandwidth}(P) = \min \{ \text{bandwidth}(e) \}$$

$$\text{bandwidth}(P) \geq B \quad (2)$$

Delay jitter constraint is shown in the formula(3):

$$\text{dj}(P) = \sum_{e \in P(E)} \text{dj}(e) + \sum_{n \in P(V)} \text{dj}(n)$$

$$\text{dj}(P) \leq DJ \quad (3)$$

Packet loss rate constraint is shown in the formula(4):

$$\text{pl}(P) = 1 - \prod_{n \in P(V)} (1 - \text{pl}(n))$$

$$\text{pl}(P) \leq PL \quad (4)$$

Among them, P is the routing path for the source point to the destination. The bandwidth, delay, delay jitter and packet loss rate are respectively B, D, DJ, DL.

Ant colony algorithm based on optimization sorting

Foraging behavior is an important and interesting behavior of ant colony, Ants have the ability to find the shortest path to the food source without any visible prompt in nature. The study found that the previous ants will leave the pheromone in the path, and then more ants will choose this path. Based on this positive feedback mechanism, the ants can find the shortest path from their nest to food.

Restriction of pheromone trail

In order to avoid the stagnation resulted from the dramatic difference between the pheromone of the track in the operation of the algorithm, the pheromone is limited to a maximum and minimum range here, then it is always in a reasonable space to produce an effect on the algorithm[5].

The improved rule is shown in the formula(5):

$$\tau_{ij}(t) = \begin{cases} \tau_{\min}, & \tau_{ij}(t) < \tau_{\min} \\ \tau_{ij}(t), & \tau_{\min} \leq \tau_{ij}(t) \leq \tau_{\max} \\ \tau_{\max}, & \tau_{ij}(t) > \tau_{\max} \end{cases} \quad (5)$$

Improvement of pheromone update

In the most ant colony algorithms, the global update rule is applied to the optimal ant path in order to enhance the ability of ant colony optimization. However, in each iteration, especially in the early stage of the algorithm, the solution of the optimal path may have a large deviation. At the same time, the situation that the path with the most pheromone is not the best path still exists. Owing to the positive feedback, this pheromone may not belong to optimal path has undue enhancement[6]. This requires us not only to respond to the optimal solution, but also to try to find more possible solutions. Some research has found that if a solution is good, the more better solution may occur in its vicinity.

Based on the above considerations, this paper chooses a combination of their respective advantage solutions in the last three iterations to be the value of the optimal path. This not only enrich the solution space, but also let the ants will not select too bad solution in the path.

Assuming that optimal solution of this iteration is L_{best}^n at the N iteration, the optimal solution of its previous two iterations respectively are L_{best}^{n-1} and L_{best}^{n-2} . They sort according to the length of the path, and get a pheromone update contribution value in accordance with this ranking, the shorter the path is, the greater it impacts on the future. At the same time, according to the experience, if the time that we make choice is closer, this choice impacts greater. Therefore, in this algorithm, for the

solution at the N iteration, the value of the optimal solution at the N-1 iteration is more attractive than it at the N-2 iteration. Thus, they also sort according to the iteration time, and get a pheromone update contribution value in accordance with this ranking.

pheromone updating rule in accordance with the path ranking is shown in the formula(6):

$$\Delta \tau_{ij}^{\mu} = \begin{cases} \frac{\sum \left((\sigma - \mu_n) \cdot \frac{Q}{L_{best}^n} \right)}{\sum (\sigma - \mu_n)} & \text{Ant}(\mu_n) \text{ walks through the path}(i, j) \\ 0 & \text{Otherwise} \end{cases} \quad (6)$$

Among them, μ_n is serial number arranged by the path ranking, L_{best}^n is path length this ant walks, σ is interference factor of path. Because this algorithm only takes the influence of the last three iterations, σ takes value with [4,6] in order to make a reasonable interference.

pheromone updating rule in accordance with the iteration ranking is shown in the formula(7):

$$\Delta \tau_{ij}^{\nu} = \begin{cases} \frac{\sum \left((\varepsilon - \nu_n) \cdot \frac{Q}{L_{best}^n} \right)}{\sum (\varepsilon - \nu_n)} & \text{Ant}(\nu_n) \text{ walks through the path}(i, j) \\ 0 & \text{Otherwise} \end{cases} \quad (7)$$

Among them, ν_n is serial number arranged by the iteration ranking, L_{best}^n is path length this ant walks, ε is interference factor of iteration. Because this algorithm only takes the influence of the last three iterations, ε takes value with [4,6] in order to make a reasonable interference.

The final pheromone updating rule is shown in the formula(8):

$$\tau_{ij}(t+n) = (1-\rho)\tau_{ij}(t) + \Delta \tau_{ij}$$

$$\Delta \tau_{ij} = \begin{cases} \frac{a \times \Delta \tau_{ij}^{\mu} + b \times \Delta \tau_{ij}^{\nu}}{a+b} & \text{Iteration } n \geq 3 \\ \frac{Q}{L_{best}^n} & \text{Iteration } n < 3 \end{cases} \quad (8)$$

a is weight coefficient of path influence, b is weight coefficient of iteration influence, $\Delta \tau_{ij}$ is pheromone increment in global updating of the algorithm.

Simulation experiment and analysis

For the simulation experiment, this paper uses Figure 1 as network topology graph, and describes QoS constraint of link as (bandwidth, delay, cost).

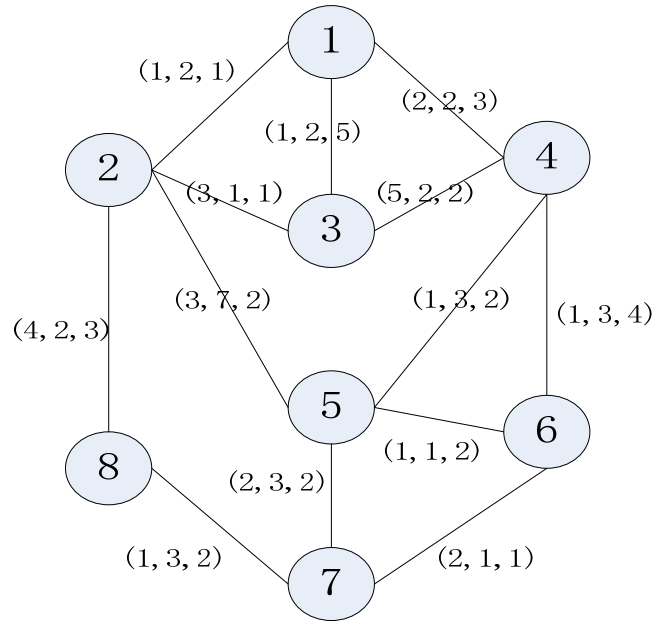


Fig.1. Network topology

In this simulation, the parameters are set as follows: $m=8$, $n=30$, $\alpha=1$, $\beta=5$, $\rho=0.5$, $Q=100$, $D=10$, $B=4$, source node is 1, target node is 7.

Among them, m is number of ants, n is iteration time, α is pheromone influence factor, β is heuristic information influence factor, ρ is pheromone evaporation coefficient, Q is pheromone intensity, D is delay constraint, B is bandwidth constraint.

The optimal routing is 1-2-8-7, its minimum cost is 6, at the same its time delay is 7 which meets delay constraints.

The convergence of basic ant colony algorithm and RRB-AS algorithm is shown in Figure 2. We can clearly see from the figure, although the two algorithms can both converge at the cost of 6, the RRB-AS algorithm is significantly quicker than the basic ant colony algorithm at iteration time, and more stable than the basic ant colony algorithm.

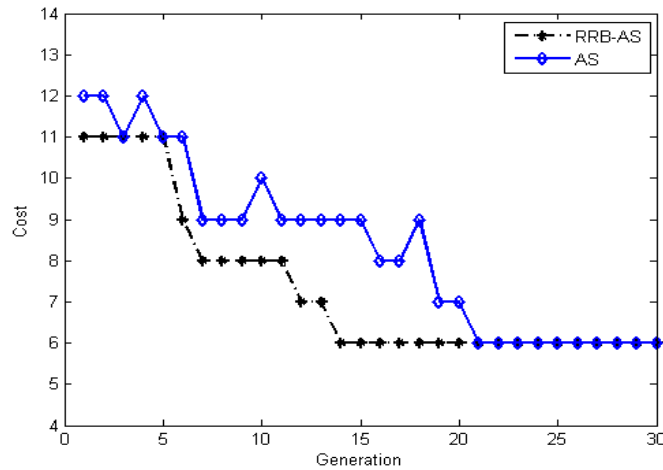


Fig.2. Convergence of AS and RRB-AS algorithm

The simulation results show that the proposed RRB-AS algorithm can effectively overcome the problem of slow convergence speed in ant colony algorithm, and make it more stable. This algorithm gets the expected results.

Conclusion

Aiming at the problem of slow convergence speed of ant colony algorithm, this paper proposes a RRB-AS algorithm. Finally, the improved algorithm is applied in QoS routing, and is simulated with the network of 8 nodes. The results show that the improved algorithm is better than the basic

ant colony algorithm in the convergence speed, and the stability of the algorithm has been greatly improved. However, in reality, the network size is generally relatively large, the algorithm is still applicable in the large-scale network environment theoretically, but this paper does not carry out the corresponding simulation verification.

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