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Optimization of Cold Chain Logistics Path of Vietnam's Agricultural Products based on Improved Genetic Algorithm

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Abstract

The impact of the new crown epidemic has forced an increase in the cost of agricultural products in Vietnam. Optimizing the cold chain logistics distribution path can help reduce distribution costs and deliver goods safely and quickly. First, this article analyzes in detail the components of the cold chain distribution cost of agricultural products, including fixed costs, transportation costs, cargo damage costs and penalty costs; secondly, combining the results of cold chain logistics cost analysis, constructs a route optimization model for agricultural products multi-distribution centers under time window constraints ; Thirdly, based on the basic idea of the standard genetic algorithm, an improved genetic algorithm is proposed for the optimization of mathematical models; finally, the feasibility of the improved genetic algorithm is verified, and it is proved that the algorithm is more conducive to obtaining the optimal solution of the model. Solving the vehicle routing problem has applicability and effectiveness.

Keywords

Imported Agricultural Products; Cold Chain Logistics; Route Optimization; Improved Genetic Algorithm.

1. Introduction

As the new crown epidemic is gradually brought under control, the Ministry of Industry and Trade of Vietnam proposes to restore the provincial ports that cross the Sino-Vietnamese border and gradually restore economic and trade exchanges between the two countries. However, Vietnam's current customs clearance capacity has not been fully restored. Only some ports between Vietnam and China have resumed customs clearance. Therefore, the customs clearance and export of agricultural products are still being squeezed, and the cost is forced to increase, so that customers can enjoy Wumart. Inexpensive agricultural products are essential to reduce product logistics and distribution costs. Optimizing the cold chain logistics distribution path will not only improve the delivery timeliness, reduce the deterioration and damage of agricultural products, but also shorten the distribution distance and reduce the cost of distribution, which is conducive to the safe and rapid delivery of cold chain agricultural products to customers and improve logistics Service Level.

Many scholars at home and abroad have carried out in-depth research on the problem of logistics distribution route optimization. Foreign countries have a relatively early understanding of the problem of vehicle routing optimization. Dantzig and Ramser first proposed the VRP problem (Vehicle Routing Problem) in 1959. Since then, more and more scholars have carried out research in this area, which can be summarized into the following aspects:

(1) Research on logistics and distribution problems considering traffic congestion: In recent years, with the increase in private cars, the problem of urban road congestion has become more and more serious. Under such circumstances, some scholars at home and abroad began to

gradually regard traffic congestion as a key factor in studying the related issues of logistics and distribution. From the two dimensions of the number of enterprise distribution centers and customer demand, Konur et al. analyzed how companies deal with the adverse effects of traffic congestion on the company by constructing the cost of traffic congestion [5].

(2) Establishment of delivery vehicle routing optimization model: Ana Osvald and Lidija Zadnik Stir proposed a vehicle routing optimization model for the delivery of fresh vegetables. This model takes into account the time window factor. He believes that different periods of the day will also affect the delivery time. , The model also calculates the spoilage of fresh food as part of the distribution cost, and verifies it with an example [6]; Wen Fengxian studied the problem of aquatic product distribution route under the condition of uncertain demand, assuming that all customers When the demand for aquatic products exists probabilistically, a multi-objective mathematical model is constructed, combined with the improved ant colony algorithm to solve the aquatic product distribution route optimization method [11].

(3) VRPTW problem solving: Solomon et al. first studied the vehicle routing problem with time constraints, that is, the VRPTW (Vehicle Routing Problem with Time Windows) problem. Since then, there has been an upsurge in studying VRPTW [1-2]. Mehdi Adelzadeh et al. studied the vehicle path optimization problem with fuzzy time windows for multiple warehouses and multiple types of vehicles. They constructed a multi-objective optimization model with the shortest service time and shortest route as the goal, and improved the simulated annealing algorithm to solve the model, and finally proved that the method can be used for practical problems [7]; HSU et al. established the cost of energy consumption The goal is to minimize the penalty cost for violating the customer's time window, and the problem of perishable product distribution route optimization with time window is the goal. It is proposed that the standard of perishability is added to the key considerations to deliver fresh vegetables, and a vehicle routing optimization model based on customer time windows and delivery time windows is established [10].

2. Problem Description

Vietnam is located in the tropics, with high production of fruits and vegetables and large exports. As the main export market for Vietnam's fruits and vegetables, China maintains a good cross-border trade cooperation relationship between China and Vietnam, which is beneficial to the economic development of both countries. However, due to the impact of the new crown epidemic, Vietnam's exports of fruits and vegetables have dropped significantly. In order to reduce cold chain logistics costs, shorten the transportation cycle of fruits and vegetables, and help increase sales to a certain extent, it is necessary to rationally optimize distribution routes and provide low-consumption and high-efficiency transportation services. This article takes the Sino-Vietnamese cross-border trade of fruits and vegetables as an example, focusing on the cold chain logistics and distribution process of Vietnamese fruits and vegetables after reaching multiple Chinese imported vegetable and fruit markets, and then transporting them to major imported fruits and vegetables demand points, and establishing a distribution path with the goal of the lowest comprehensive cost. Optimize the model, and conduct analysis and research on this.

In order to better define the problems to be studied, this article proposes the following hypotheses: (1) The market provides distribution services to customers, and the market is regarded as a distribution center to deliver goods to surrounding customers; (2) The distribution center will provide Carry out reasonable dispatch, each customer is delivered by a vehicle, and the customer demand is less than the load of the vehicle; (3) The delivery vehicle starts from the distribution center and returns to the distribution center after completing the task; (4) During the distribution process, the refrigerated truck The outside temperature

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remains the same; (5) During the distribution process, the quality of agricultural products will not be lost.

3. Model Establishment

3.1. Symbol Description

This paper studies the distribution of N demand points in multiple imported vegetable and fruit markets. The symbols in the model and their specific meanings are shown in Table 1:

Table 1. Symbols and their meanings

symbol	meaning
C_z	overall costs
C_1	Fixed cost
C_2	transportation cost
C_3	Agricultural product wastage cost
C_4	Penalty cost
F_k	Fixed cost of the kth car
K	Total number of vehicles
C_{ij}^k	The fuel and tolls required for the k-th vehicle to travel from demand point i to demand point j
W_{ij}^k	The cost of refrigeration required to deliver 1 unit of fruits and vegetables for 1 km
S_{0i}^k	The distance traveled by the k-th vehicle from the distribution center to the demand point i
S_{ij}^k	The distance traveled by the k-th car from demand point i to demand point j
q_i	Demand point i order weight of fruits and vegetables
Q	Maximum load-bearing capacity of all vehicles
r	Damage rate of goods during delivery
p_1	Unit value of fruit and vegetable products
∂_1, ∂_2	Penalty coefficient
$[T_{Ei}, T_{Hi}]$	Service time window that demand point i can accept
$[T_{ei}, T_{hi}]$	Service time window expected by demand point i
M	The delivery time cannot be accepted by the customer, and the immeasurable loss needs to be accepted
t_0^i	Time when vehicle k departs from the distribution center
t_i^k	Time from vehicle k to demand point i
t_{ij}^k	It takes time for vehicle k from demand point i to demand point j
t_j^k	Time from vehicle k to demand point j
x_k(0/1variable)	x_i=0: the kth car is not used; x_i=1: the kth car is used
y_{ki}(0/1variable)	y_{ki}=0: vehicle k does not serve demand point i; y_{ki}=1: vehicle k serves demand point i
s_{kij}(0/1variable)	s_{kij}=0: Vehicle k has not passed the road section (i, j); s_{kij}=1: Vehicle k has passed the road section (i, j)
N	Number of demand points

3.2. Cost Analysis

Through the research and investigation of the imported vegetable and fruit market, and understanding the local distribution situation, a functional model including fixed cost, transportation cost, agricultural product loss cost and penalty cost is established. This section elaborates on each type of cost.

3.2.1. Fixed Costs

Through the survey, it is learned that the fixed cost of logistics distribution vehicles includes vehicle depreciation, maintenance fees, and driver's salary. The total fixed cost is directly proportional to the number of vehicles participating in the distribution. Therefore, the fixed cost can be expressed as:

$$C_1 = \sum_{k\in K} (F_k)$$

3.2.2. Transportation Cost

The transportation cost includes the fuel cost, the toll cost and the refrigeration cost provided for the goods during the transportation of the delivery vehicle. The transportation cost expression is:

$$C_2 = \sum_{k=1}^{K} \sum_{i,j=0}^{N} C_{ij}^k x_k s_{kij} + \sum_{k=1}^{K} \sum_{i,j=0}^{N} \sum_{q=q_1}^{q_n} W_{ij}^k x_k y_{ki} s_{kij}$$

3.2.3. Agricultural Product Loss Cost

During the distribution process, the quality of agricultural products may be damaged due to collisions, respiration, etc. In this model, the loss cost of agricultural products is expressed as:

$$C_3 = \sum_{k=1}^{K} \sum_{i,j=0}^{N} y_{ki} p_1 q_i r[1 - e^{-a} (t_j^k - t_0^i)]$$

3.2.4. Penalty Costs

This study adopts the soft time window constraint. If fresh products are delivered outside the $[T_{Ei}, T_{Hi}]$time window and the demand point i refuses to accept it, the time penalty cost is infinite (denoted by M), and the penalty cost function is as follows:

$$C_{4i} = \begin{cases} M & t_i^k < T_{hi} \\ \partial_1 (T_{Hi} - T_{hi}) & T_{hi} \leq t_i^k \leq T_{Hi} \\ 0 & T_{ei} < t_i^k < T_{hi} \\ \partial_2 (T_{ei} - T_{Ei}) & T_{ei} \leq t_i^k \leq T_{Ei} \\ M & t_i^k > T_{Ei} \end{cases}$$

Therefore, the total time penalty cost can be expressed as:

$$C_4 = \sum_{k=1}^{K} \sum_{i=1}^{N} C_{5i}$$

3.3. Model Establishment

In summary, the construction model of this research can be expressed as:

$$C_z = \min\{\sum_{k\in K}(F_k) + \sum_{k=1}^{K}\sum_{i,j=0}^{N} C_{ij}^{k} x_k s_{kij} + \sum_{k=1}^{K}\sum_{i,j=0}^{N}\sum_{q=q_1}^{q_n} W_{ij}^{k} x_k y_{ki} s_{kij}$$

$$+ \sum_{k=1}^{K}\sum_{i,j=0}^{N} y_{ki} p_1 q_i r[1 - e^{-a}(t_j^k - t_0^i)] + \sum_{k=1}^{K}\sum_{i=1}^{N} C_{5i}\}$$

$s.t.$

$$\sum_{k=1}^{K}\sum_{i=1}^{n} y_{ki} = N \quad i = 1,2,3 \dots, n; k = 1,2,3, \dots, k$$

$$\sum_{i=1}^{N} y_{ki} q_i \le Q$$

$$\sum_{i=1}^{n} y_{ki} = 1 \qquad i = 1,2,3, \dots, n$$

$$\sum_{i=1}^{n} y_{ki} = K \qquad i = 0$$

4. Algorithm Design

4.1. Basic Idea

In order to avoid the shortcomings of standard genetic algorithms that are easy to mature, slow to converge, and fall into local optima in the optimization process, this paper improves the standard genetic algorithm, which is mainly reflected in three aspects: First, design the operator to make the genetic algorithm have The characteristics of the spiral spiral; second, design adaptive crossover rate and mutation rate; third, combine the idea of greedy algorithm to improve the optimization speed.

The decisive role in the genetic algorithm is the crossover operator and the mutation operator. If the crossover rate is relatively large, although it can strengthen the algorithm's ability to find new search areas, genes with high fitness values are easily destroyed, making the search tend to be random and meaningless. The crossover probability of a general genetic algorithm usually uses a constant. However, when the crossover rate is constant, no matter how much the constant value is, it cannot be well adapted to the quality of different individuals. If the crossover rate is large, the fitness of the individual at the beginning of the iteration is relatively low. When the crossover rate is large, the search ability of the genetic algorithm can be improved. However, at the end of the iteration, the fitness of the individual is relatively high. At this time, if the crossover rate is too large, the good genes may be destroyed; when the crossover rate is small, the situation is just the opposite. Therefore, when the crossover rate is constant, the quality of the solution cannot be improved well. The probability of mutation determines whether the chromosome is mutated. When the mutation probability is too large, the genetic algorithm can easily be transformed into a random algorithm; when the mutation probability is small, no new chromosomes can be generated. Therefore, the selection of adaptive crossover probability and mutation probability can improve the search ability of genetic algorithm.

Greedy algorithm can make the best choice in the current situation when solving the problem. This idea is not to consider from the perspective of overall optimality, but to obtain a local

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optimal solution in a certain sense. Therefore, this article optimizes the case based on the improved genetic algorithm combined with the idea of greed to improve the convergence speed of the algorithm.

4.2. Improved Genetic Algorithm Design

The design to improve the spiraling characteristics of genetic algorithm is: first use combinatorial operators to perform genetic operations on the algebra specified by population evolution (increasing or not decreasing the average population fitness), then reorganize the excellent individuals retained in history, and finally follow The adaptive crossover rate and mutation rate evolve the individuals in the population, thus forming a cyclic evolution process. After several such cyclic evolution processes, the optimal solution is finally obtained. The spirality involves the following operators:

(1) Combination operator is a new operator designed for genetic algorithm. It operates in four steps, assuming that the parent is F.

Step 1: Randomly select two customer points g and h from the parent F;

Step 2: Reverse the order of the customer points between g and h (including g and h). If the F fitness value becomes larger after the reverse order, reverse the order of the customer points between g and h and modify The fitness value of F;

Step 3: Select two customer points g and h successively;

Step 4: Insert customer g in front of customer h. If the fitness value of F becomes larger, insert customer g in front of customer h, and modify the fitness value of F.

After four steps, the combination operator operation is completed, and the fitness value of the individuals in the group is also calculated. The combination operator operation ends, and the fitness value of the individuals in the generated population is recalculated at the same time. There are two main reasons why the combination operator can maintain the evolutionary trend of the population: First, when the combination operator is executed, the fitness value of the offspring produced is higher than the fitness value of the parent, or equal to the fitness value of the parent; The second is that if the conditions in step 2 and step 4 cannot be satisfied, the operator is equivalent to a copy operation, otherwise it is a mutation operation.

(2) Crossover operator, suppose the parent is FA and FB.

First, randomly select a customer point g from any parent, and then use g as the starting point to use the cyclic crossover operator to operate, and replace the parent FA and FB with the generated offspring FA' and FB'.

(3) Mutation operator, assuming that the parent is F.

Randomly select two customer points g and h in the parent generation, then swap the positions of g and h, and modify the fitness value of F.

The cyclic evolution process of the improved genetic algorithm is to first use the combination operator to operate the population, and then to reorganize the population of the optimal individual. Finally, according to the adaptive crossover probability and mutation probability, the individuals in the population are genetically manipulated to produce the next generation of individuals. In this paper, the adaptive crossover rate and mutation rate are designed to solve the path optimization problem. The formula for adaptive crossover rate and mutation rate is as follows:

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$$P_c=\begin{cases} P_{c1}-\dfrac{(P_{c1}-P_{c2})\times(f'-\overline{f})}{f_{MAX}-\overline{f}}, & f \geq \overline{f} \\ P_{c1}, & f'<\overline{f} \end{cases}$$

$$P_m=\begin{cases} P_{m1}-\dfrac{(P_{m1}-P_{m2})\times(f_{MAX}-f)}{f_{MAX}-f}, & f \geq \overline{f} \\ P_{m1}, & f<\overline{f} \end{cases}$$

5. Example Analysis

Through the investigation and investigation of three imported vegetable and fruit markets, MATLAB2012a is used to optimize the distribution path of fruit and vegetable products. Set the population size N=200, the genetic algebra included in an evolution cycle process is EG=10, the maximum evolution cycle number EC=200, Pc_1=0.9, Pc_2=0.6, Pm_1=0.1, Pm_2=0.001. The specific optimization results are shown in Table 2 and Table 3.

Table 2. Distribution plan

S1	T1	S1-C16-C27-C23-C11-C7-S1 7:10-8:02-9:04-10:05-11:26-12:21-14:02	29	82.9%
S1	T2	S1-C28-C15-C19-C22-C26-S1 7:15-8:28-9:27-11:15-12:07-13:50-14:51	30	85.7%
S2	T3	S2-C10-C21-C12-C14-C8-S2 7:25-8:21-9:43-11:22-13:05-14:06-15:08	28	80.0%
S2	T4	S2-C4-C6-C5-C2-C18-C30-C24-S2 7:30-8:20-9:21-10:07-11:10-12:11-12:59-14:23-15:20	30	85.7%
S3	T5	S3-C29-C9-C1-C17-S3 7:40-9:12-10:01-10:54-11:55-13:16	31	88.6%
S3	T6	S3-C20-C25-C3-C13-S3 7:45-9:26-10:15-11:17-12:14-14:05	33	94.3%

Table 3. Distribution cost information

S1	85.5	50	42.75	2.5	0	95.25	90.3%
S1	115.12	50	57.56	4.3	0	111.86	87.9%
S2	129.88	50	64.94	0	0	114.94	100%
S2	112.69	50	56.35	0	0	106.35	98.5%
S3	94.15	50	47.08	2.1	0	99.18	100%
S3	87.38	50	43.69	3.7	0	97.39	95.3%

In order to further verify the feasibility of the plan, the scientific rationality of the transportation plan is tested from the following aspects:

1. Reasonability of the distribution route: After the six refrigerated trucks carrying out the distribution task depart from each distribution center, they will perform the delivery service for the customers in turn and then return to the distribution center. The transportation route of the six refrigerated trucks avoids the phenomenon of repeated driving and crossing circuits. Therefore, from the perspective of the geometry of the distribution route, the design of the driving scheme is more scientific and reasonable, which improves the efficiency of logistics distribution.

2. Distribution cost analysis: The optimized calculation results show that this distribution task requires 6 refrigerated trucks, and the total distribution cost is 624.97 yuan, of which the loss cost of agricultural products is lower and the penalty cost is 0. Therefore, from a cost perspective, the transportation route is more reasonable.

3. Refrigerated truck capacity constraints: as shown in Table 2, the total freight volume of each route obtained by this model is less than the maximum load of the refrigerated truck, and the vehicle loading rate is also high, and there is no idling or Overload phenomenon.

6. Performance Testing

6.1. Optimal Solution Convergence Detection

Figure 1 shows the change of the population fitness value when the improved genetic algorithm is used to solve the distribution route optimization problem in this paper. As shown in the figure, in the early stage of optimization, because the initial population contains a lot of poor quality chromosomes, such as the driving route corresponding to the chromosome does not meet the vehicle capacity constraint, or does not meet the customer time window requirements, the penalty cost is paid, so the objective function of the population The value is at a high level. However, in the early stage of searching the solution space of the algorithm, it can be seen that the curve of the objective function value drops significantly. With the advancement of genetic evolution, the downward trend of the curve becomes slower and gradually stabilizes. This is because the violations are constantly eliminated in the algorithm solving process. Constrain the chromosomes of the conditions, and reorganize the superior chromosomes in the parent generation into the next-generation population, so that the search will converge towards the target optimal trend. When EC=200, the population target value tends to be stable and the optimal solution is reached. When the improved genetic algorithm is used in this paper to optimize the distribution route problem, the convergence trend of the objective function value in the optimization process shows the feasibility of the algorithm.

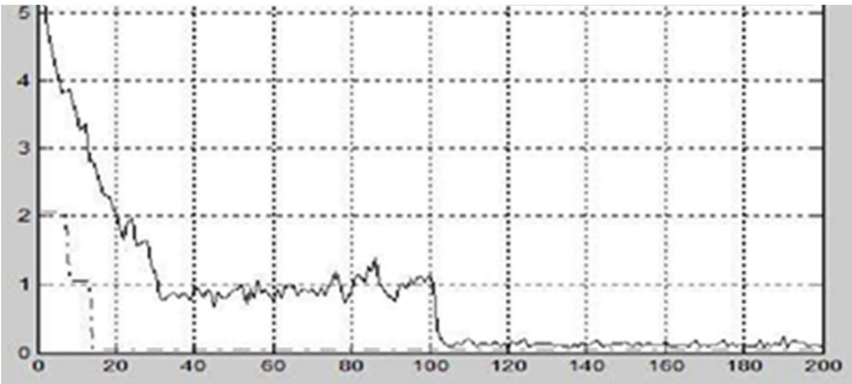

Figure 1. Trend of population fitness value change

6.2. Improved Genetic Algorithm Performance Testing

Table 4 compares and analyzes the improved genetic algorithm proposed in this paper with the standard genetic algorithm and the traditional partheno genetic algorithm. The fitness function value is used as the comparison standard. The fitness value is the best. Random operations are performed 10 times, and the population size is set to 200. , The maximum number of cycles is 200, and the calculation results are shown in Table 4.

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Table 4. Comparison of improved genetic algorithm with standard genetic algorithm and partheno genetic algorithm

1	2	3	4	5	6	7	8	9	10
3.575	3.656	3.573	3.568	3.590	3.599	3.593	3.516	3.612	3.522
3.614	3.567	3.532	3.522	3.516	3.534	3.549	3.551	3.514	3.531
3.711	3.700	3.722	3.703	3.702	3.695	3.708	3.700	3.693	3.712

Note: The first group in the table is the calculation result of the standard genetic algorithm (Pc=0.8, Pm=0.05); the second group is the calculation result of the partheno genetic algorithm; the third group is the calculation result of the improved genetic algorithm.

It can be seen from Table 4 that when the parameters are roughly the same, the result obtained by the improved genetic algorithm is closer to the optimal solution. Compared with the standard genetic algorithm, the improved genetic algorithm designed in this paper avoids the shortcomings of easy maturity, slow convergence speed and weak local search ability in the optimization process; compared with the partheno genetic algorithm, it not only retains the crossover and the standard genetic algorithm Mutation operation, and the crossover probability and mutation probability are improved, avoiding the disadvantage that the insertion operator in the partheno genetic algorithm may cause damage to the good gene fragments. On the whole, the improved genetic algorithm in this paper has strong global search performance and is more conducive to obtaining the optimal solution of the model. It is an effective method to solve the vehicle routing problem.

7. Summary

In summary, using the model and optimization algorithm constructed in this article to solve the results can effectively improve the efficiency of cold chain distribution of agricultural products, the loading rate of refrigerated trucks, reduce the cost of cold chain logistics distribution, optimize the distribution path, and provide guidance for the distribution of agricultural products. Suggest. The specific research results are as follows:

(1) This paper analyzes in detail the composition of cold chain logistics distribution costs. Aiming at the various drawbacks of the city’s single distribution center logistics model, this paper proposes a multi-distribution center agricultural product distribution model, and optimizes the urban multi-distribution center path, which is effective Improve logistics efficiency and customer satisfaction, and reduce logistics costs.

(2) The problem of vehicle routing is studied, and the composition of the cold chain logistics cost of agricultural products is analyzed in detail, including four parts: fixed cost, transportation cost, agricultural product loss cost and penalty cost. Aiming at the perishable characteristics of agricultural products and the customer's requirements for delivery time, with the goal of the lowest total cost of logistics distribution, a cold chain delivery path optimization model for agricultural products with time windows is established.

(3) Aiming at the optimization problem of urban cold chain logistics distribution routes for agricultural products, this paper first uses the minimum envelope clustering method to determine the customers responsible for each distribution center, and then proposes an improved genetic algorithm to guide the distribution based on the basic process of the standard genetic algorithm The path is optimized and solved, and the design ideas and algorithm steps of the improved genetic algorithm are described in detail.

(4) According to the agricultural product urban cold chain distribution model and improved genetic algorithm proposed in this paper, taking specific agricultural product e-commerce

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companies as an example, using MATLAB to optimize and analyze the vehicle routing model, the results show that the delivery route is reasonable and the cost is better. And it meets the customer's time window requirements, which verifies the rationality of the model. The performance of the improved genetic algorithm was further tested through experimental comparison analysis. The experimental results show that the improved genetic algorithm has strong global search capabilities and can obtain the optimal solution quickly, which proves the applicability and applicability of the improved genetic algorithm for optimizing vehicle routing problems. Effectiveness.

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