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On Trapezoidal Fuzzy Transportation Problem using Zero Termination Method

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Abstract

In this paper, fuzzy transportation problem is investigated using zero termination method. The Transportation costs, supply and demand values are considered to lie in an interval of values. Fuzzy modified distribution method is proposed to find the optimal solution in terms offuzzy numbers. The solution procedure is illustrated with a numerical example.

Keywords: Trapezoidal fuzzy numbers, Fuzzy trapezoidal membership function, Fuzzy Transportation Problem, Zero termination method

1 INTRODUCTION

Transportation problem deals Transportation problem with the distribution of a product from various sources to different destinations of demand, in such a manner that the total transportation cost is minimized. In order to solve a transportation problem, the decision parameters such as availability, requirement and the unit transportation cost of the model were tried at crisp values. But in real life, supply, demand and unit life transportation cost are uncertain due to several factors. These imprecise data may be represented by fuzzy numbers. To deal with this uncertain situations in transportation problems many researchers [3, 5, 6, 9] have proposed fuzzy and interval programming techniques for solving the transportation problem.

The concept of fuzzy mathematical programming on a general level was first proposed by Tanaka etal 1974 in the frame work of fuzzy decision of Bellman and Zadeh [1].

Des et al [4], proposed a method, using fuzzy technique to solve interval transportation problems by considering the right bound and the midpoint interval and T.K.Pal [7] proposed a new orientated method to solve interval transportation problems by considering the midpoint and width of the interval in the objective function. Stephen Dinagara D Palanivel K[10] proposed method of finding the initial fuzzy feasible solution to a fuzzy transportation problem. But most of the existing techniques provide only crisp solution for fuzzy transportation problem. In general, most of the authors obtained the crisp optimal solution to a given fuzzy transportation problem. In this paper, we propose a new algorithm to find the initial fuzzy feasible solution to a fuzzy transportation problem without converting it to be a classical transportation problem.

In section 2, we recall the basic concepts and results of Trapezoidal fuzzy numbers and the fuzzy transportation problem with Trapezoidal fuzzy number and their related results. In Section 3, we propose a new algorithm of fuzzy interval transportation problem. In Section 4, we propose a new algorithm to find the initial fuzzy feasible solution for the given fuzzy transportation problem and obtained the fuzzy optimal solution, applying the zero termination method. In Section 5, we brief the method of solving a fuzzy transportation problem using zero termination method on Trapezoidal fuzzy number. Numerical example is illustrated.

2. PRELIMINERIES

In this section we present some necessary definitions.

2.1 Definition

A real fuzzy number $\tilde{a}$ is a fuzzy subset of the real number R with membership function $\mu_{\tilde{a}}$ satisfying the following conditions.

1. $\mu_{\tilde{a}}$ is continuous from R to the closed interval [0,1]
2. $\mu_{\tilde{a}}$ is strictly increasing and continuous on $[a_1,a_2]$
3. $\mu_{\tilde{a}}$=1in $[a_2,a_3]$
4. $\mu_{\tilde{a}}$ is strictly decreasing and continuous on $[a_3,a_4]$ where a_1,a_2 ,a_3&a_4 are real numbers, and the fuzzy number denoted by $\tilde{a}$= $[a_1,a_2,a_3,a_4]$is called a trapezoidal fuzzy number.

2.2 Definition.

The fuzzy number is a trapezoidal number, and its membership function $\mu_{\tilde{a}}$ is represented by the figure given below.

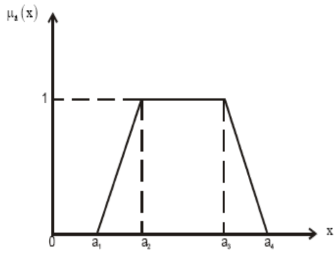

Figure.1 .Membership function of a fuzzy number - a

2.3 Definition.

We define a ranking function μ: F(μ) → μ, which maps each fuzzy number into the real line ,F(μ) represents the set of all trapezoidal fuzzy numbers. If μ be any ranking function,

Then μ ($\tilde{a}$) =(a_1+a_2 +a_3 +a_4)/4 .

2.4 Arithmetic operations

Let $\tilde{a}$=[a_1,a_2 ,a_3 ,a_4]and $\tilde{b}$=[b_1,b_2 ,b_3 ,b_4] be two trapezoidal fuzzy numbers then the arithmetic operations on $\tilde{a}$ and $\tilde{b}$ are defined as follows :

- Addition: $\tilde{a} + \tilde{b}$= (a_1+b_1,a_2+b_2,a_3+b_3,a_4+b_4)
- Subtraction: $\tilde{a}$-$\tilde{b}$= (a_1-b_4 , a_2-b_3 ,a_3-b_2 ,a_4-b_1)
- Multiplication:$\tilde{a}*\tilde{b}$ = [min($a_1b_1, a_1b_4, a_4b_1, a_4b_4$) , min($a_2b_2, a_2b_3, a_3b_2, a_3b_3$) , max($a_1b_1, a_1b_4, a_4b_1, a_4b_4$) , max ($a_2b_2, a_2b_3, a_3b_2, a_3b_3$)]

2.5. Fuzzy Solution;

A set of allocation x_{ij} which satisfies the row and column restriction is called a fuzzy solution.

2.6. Fuzzy feasible solution;

Any fuzzy solution $\{x_{ij}\ ,\ x_{ij} \geq 0\}$ is called fuzzy feasible solution.

2.7. Fuzzy basic feasible solution;

A fuzzy feasible solution to a fuzzy transportation problem with m sources and n destinations is said to be a fuzzy basic feasible solution if the number of positive allocations (m+n-1).

***2.8. Fuzzy degenerate feasible solution*;**

If the number of allocations in a fuzzy solution is less than (m+n-1), it is called a fuzzy degenerate feasible solution.

2.9Fuzzy optimal cost;

A fuzzy feasible solution is said to be a fuzzy optimal solution if it minimizes the total fuzzy transportation cost.

3.FUZZY TRANSPORTATION PROBLEM

Let us consider a transportation system based on fuzzy with m fuzzy origins and n fuzzy destinations. Let us further assume that the transportation cost of one unit of product from ith fuzzy origin to jth fuzzy destination be denoted by C_{ij}=[$c_{ij}^{(1)}$,$c_{ij}^{(2)}$,$c_{ij}^{(3)}$,$c_{ij}^{(4)}$], the availability of commodity at fuzzy origin i be s_i=[$s_i^{(1)}$,$s_i^{(2)}$,$s_i^{(3)}$,$s_i^{(4)}$], commodity needed at the fuzzy destination j be d_j=[$d_j^{(1)}$,$d_j^{(2)}$,$d_j^{(3)}$,$d_j^{(4)}$]. The quantity transported from ith fuzzy origin to jth fuzzy destination be X_{ij}=[$x_{ij}^{(1)}$,$x_{ij}^{(2)}$,$x_{ij}^{(3)}$,$x_{ij}^{(4)}$].

Now, the fuzzy transportation problem based on supply s_i, demand d_i and the transported quantity X_{ij} can be related in a table as follows.

	1	2…	N	Fuzzy capacity
1	C_{11} X_{11}	C_{12}… X_{12}…	C_{1n} X_{1n}	s_1
2 . . .	C_{21} X_{21}	C_{22}… X_{22}…	C_{1n} X_{2n}	s_2
M	C_{m1} X_{m1}	C_{m2}… Xm_2…	C_{mn} X_{mn}	S_m
Fuzzy demand	d_1	d_2	d_n	$\sum d_j = \sum s_i$

Where C_{ij}=[$c_{ij}^{(1)}$,$c_{ij}^{(2)}$,$c_{ij}^{(3)}$,$c_{ij}^{(4)}$] , X_{ij}=[$x_{ij}^{(1)}$,$x_{ij}^{(2)}$,$x_{ij}^{(3)}$,$x_{ij}^{(4)}$] , s_i=[$s_i^{(1)}$,$s_i^{(2)}$,$s_i^{(3)}$,$s_i^{(4)}$] and d_i=[$d_i^{(1)}$,$d_i^{(2)}$,$d_i^{(3)}$,$d_i^{(4)}$]

The linear programing model representing the fuzzy transportation is given by

$$MinimizeZ = \sum_{i=1}^{m} \sum_{j=1}^{n} [\, c_{ij}^{(1)}, c_{ij}^{(2)} c_{ij}^{(3)}, c_{ij}^{(4)}]\ [X_{ij}^{(1)}, X_{ij}^{(2)}, X_{ij}^{(3)}, X_{ij}^{(4)}]$$

Subject to the constraints

$$\sum_{i=1}^{n} [x_{ij}^{(1)}, x_{ij}^{(2)}, x_{ij}^{(3)}, x_{ij}^{(4)}] = [s_i^{(1)}, s_i^{(2)}, s_i^{(3)}, s_i^{(4)}]$$

for i=1,2,……..m(Row sum)

$$\sum_{i=1}^{m}[X_{ij}^{(1)}, X_{ij}^{(2)}, X_{ij}^{(3)}, X_{ij}^{(4)}] = [d_j^{(1)}, d_j^{(2)}, d_j^{(3)}, d_j^{(1)}]$$

for j=1,2…n(Column sum)

$$[x_{ij}^{(1)}, x_{ij}^{(2)}, x_{ij}^{(3)}, x_{ij}^{(4)}] \geq 0$$

The given fuzzy transportation problem is said to be balanced if

$$\sum_{i=1}^{m}[s_i^{(1)}, s_i^{(2)}, s_i^{(3)}, s_i^{(4)}] = \sum_{j=1}^{n}[d_j^{(1)}, d_j^{(2)}, d_j^{(3)}, d_j^{(4)}]$$

i.e., if the total fuzzy capacity is equal to the total fuzzy demand

4. THE COMPUTATIONAL PROCEDURE FOR FUZZY MODIFIED DISTRIBUTION METHOD

4.1.Zero Termination Method

The procedure of Zero Termination method is as follows,

- Step 1: Construct the transportation table
- Step 2: Select the smallest unit transportation cost value for each row and subtract it from all costs in that row. In a similar way this process is repeated column wise.
- Step 3: In the reduced cost matrix obtained from step 2, there will be at least one zero in each row and column. Then we find the termination value of all the zeros in the reduced cost matrix, using the following rule;
- The zero termination cost is T= Sum of the costs of all the cells adjacent to zero/ Number of non- zero cells added
- Step 4: In the revised cost matrix with zero termination costs has a unique maximum T, allot the supply to that cell. If it has one (or) more Equal max values, then select the cell with the least original cost and allot the maximum possible.
- Step 5: After the allotment, the columns and rows corresponding to exhausted demands and supplies are trimmed. The resultant matrix must possess at least one zero in each row and column, else repeat step (2)
- Step 6: Repeat step (3) to step (5) until the optimal solution is obtained.

4.2. Fuzzy modified distribution method.

This proposed method is used for finding the optimal basic feasible solution in fuzzy environment and the following step by step procedure is utilized to find out the same.

1. Find a set of numbers$[u_i^{(1)}, u_i^{(2)}, u_i^{(3)}, u_i^{(4)}]$ and $[v_j^{(1)}, v_j^{(2)}, v_j^{(3)}, v_j^{(4)}]$ for each row and column satisfying $[u_i^{(1)}, u_i^{(2)}, u_i^{(3)}, u_i^{(4)}]$+$[v_j^{(1)}, v_j^{(2)}, v_j^{(3)}, v_j^{(4)}]$=$[c_{ij}^{(1)}, c_{ij}^{(2)}, c_{ij}^{(3)}, c_{ij}^{(4)}]$ for each occupied cell. To start with we assign a fuzzy zero to any row or column having maximum number of allocations. If this maximum number of

allocation is more than one, choose any one arbitrarily.

2. For each empty (un occupied) cell, we find fuzzy sum $[u_i^{(1)}, u_i^{(2)}, u_i^{(3)}, u_i^{(4)}]$ and $[v_j^{(1)}, v_j^{(2)}, v_j^{(3)}, v_j^{(4)}]$
3. Find out for each empty cell the net evaluation value $[Z_{ij}^{(1)}, Z_{ij}^{(2)}, Z_{ij}^{(3)}, Z_{ij}^{(4)}]$=$[c_{ij}^{(1)}, c_{ij}^{(2)}, c_{ij}^{(3)}, c_{ij}^{(4)}]$- $[u_i^{(1)}, u_i^{(2)}, u_i^{(3)}, u_i^{(4)}]$+$[v_j^{(1)}, v_j^{(2)}, v_j^{(3)}, v_j^{(4)}]$ this step gives the optimality conclusion

i. If all $[Z_{ij}^{(1)}, Z_{ij}^{(2)}, Z_{ij}^{(3)}, Z_{ij}^{(4)}]$>[-2,-1,0,1,2] the solution is optimal and a unique solution exists.

ii. If $[Z_{ij}^{(1)}, Z_{ij}^{(2)}, Z_{ij}^{(3)}, Z_{ij}^{(4)}]$≥[-2,-1,0,1,2] then the solution is fuzzy optimal. But an alternate solution exists.,

iii. If at least one $[Z_{ij}^{(1)}, Z_{ij}^{(2)}, Z_{ij}^{(3)}, Z_{ij}^{(4)}]$<[-2,-1,0,1,2] the solution is not fuzzy optimal. In this case we go to next step, to improve the total fuzzy transportation minimum cost.

4. Select the empty cell having the most negative value of $[Z_{ij}^{(1)}, Z_{ij}^{(2)}, Z_{ij}^{(3)}, Z_{ij}^{(4)}]$ from this cell we draw a closed path drawing horizontal and vertical lines with corner cells being occupied. Assign sign + and – alternately and find the fuzzy minimum allocation from the cells having negative sign. This allocation should be added to the allocation having negative sign.
5. The above step yield a better solution by making one(or more) occupied cell as empty and one empty cell as occupied. For this new set of fuzzy basic feasible allocation repeat the steps from [i] till an fuzzy optimal basic feasible solution is obtained.

NUMERICAL EXAMPLE

Tosolve the following fuzzytransportation problem starting with the fuzzy initial fuzzybasic feasible solution obtained by Zero Termination Method

.	FD1	FD2	FD3	FD4	Fuzzycapacity
FO1	[-2,0,2,8]	[-2,0,2,8]	[-2,0,2,8]	[-1,0,1,4]	[0,2,4,6]
FO2	[4,8,12,16]	[4,7,9,12]	[2,4,6,8]	[1,3,5,7]	[2,4,9,13]
FO3	[2,4,9,13]	[0,6,8,10]	[0,6,8,10]	[4,7,9,12]	[2,4,6,8]
Fuzzydemand	[1,3,5,7]	[0,2,4,6]	[1,3,5,7]	[1,3,5,7]	[4,10,19,27]

Since $\sum_{\mathrm{i}=1}^{\mathrm{m}} a_i = \sum_{j=1}^{n} b_j =$ [4,10,19,27], $the\ problem\ is\ balanced\ fuzzy\ transportation\ problem.$

There exists a fuzzy initial basic feasible solution.

	FD1	FD2	FD3	FD4	Fuzzycapacity
FO1	[-2,0,2,8]	[-2,0,2,8] [-7,-1,5,11]	[-2,0,2,8]	[-1,0,1,4] [-11,-3,5,13]	[0,2,4,6]
FO2	[4,8,12,16]	[4,7,9,12]	[2,4,6,8] [1,3,5,7]	[1,3,5,7] [-12,-2,8,18]	[2,4,9,13]
FO3	[2,4,9,13] [1,3,5,7]	[0,6,8,10] [-5,-1,3,7]	[0,6,8,10]	[4,7,9,12]	[2,4,6,8]
Fuzzydemand	[1,3,5,7]	[0,2,4,6]	[1,3,5,7]	[1,3,5,7]	

Since the number of occupied cell having m+n-1= 6 and are also independent , there exist a non-degenerate fuzzy basic feasible solution.

Therefore, the initial fuzzy transportation minimum cost is,

$[Z^{(1)},Z^{(2)},Z^{(3)},Z^{(4)}]=$ [-2,0,2,8][-7,-1,5,11]+[-1,0,1,4][-11,-3,5,13]+[2,4,6,8][1,3,5,7]+[1,3,5,7][-12,-2,8,18]+[2,4,9,13][1,3,5,7]+[0,6,8,10][-5,-1,3,7]

= [-56 ,-2, 10, 88]+[-44,-3, 5, 52]+[2, 12, 30, 56]+[-84, -10, 40, 126]+ [2, 12, 45, 91]+[0, -8, 24, 70]

$[Z^{(1)},Z^{(2)},Z^{(3)},Z^{(4)}]$=[-180, 1, 154 483] = 114.5

Tofind the optimal solution:

Applyingthe fuzzy modified distribution method, we determine a set of numbers $[u_i^{(1)},u_i^{(2)},u_i^{(3)},u_i^{(4)}]$and $[v_j^{(1)},v_j^{(2)},v_j^{(3)},v_j^{(4)}]$each row and column such that$[c_{ij}^{(1)}, c_{ij}^{(2)}, c_{ij}^{(3)}, c_{ij}^{(4)}]= [u_i^{(1)} , u_i^{(2)} , u_i^{(3)} , u_i^{(4)}] +[v_j^{(1)} , v_j^{(2)} , v_j^{(3)} , v_j^{(4)}]$ for each occupied cell. Since 3rdrowhas maximum numbers of allocations, we give fuzzy number

$[u_3^{(1)},u_3^{(2)},u_3^{(3)},u_3^{(4)}]=$ [-2,-1,0,1,2]. The remaining numbers can be obtained as given below.

$[c_{31}^{(1)}, c_{31}^{(2)}, c_{31}^{(3)}, c_{31}^{(4)}]= [u_3^{(1)} , u_3^{(2)} , u_3^{(3)} , u_3^{(4)}] +[v_1^{(1)} , v_1^{(2)} , v_1^{(3)} , v_1^{(4)}]$

$[v_1^{(1)} , v_1^{(2)} , v_1^{(3)} , v_1^{(4)}]= [4, 5, 8, 11]$

$[c_{32}^{(1)}, c_{32}^{(2)}, c_{32}^{(3)}, c_{32}^{(4)}]= [u_3^{(1)} , u_3^{(2)} , u_3^{(3)} , u_3^{(4)}] +[v_2^{(1)} , v_2^{(2)} , v_2^{(3)} , v_2^{(4)}]$

$[v_2^{(1)} , v_2^{(2)} , v_2^{(3)} , v_2^{(4)}]= [-2, 5, 9, 12]$

$[c_{33}^{(1)}, c_{33}^{(2)}, c_{33}^{(3)}, c_{33}^{(4)}]= [u_3^{(1)} , u_3^{(2)} , u_3^{(3)} , u_3^{(4)}] +[v_3^{(1)} , v_3^{(2)} , v_3^{(3)} , v_3^{(4)}]$

$[v_3^{(1)} , v_3^{(2)} , v_3^{(3)} , v_3^{(4)}]= [-2, 5, 9, 12]$

$[c_{23}^{(1)}, c_{23}^{(2)}, c_{23}^{(3)}, c_{23}^{(4)}]= [u_2^{(1)} , u_2^{(2)} , u_2^{(3)} , u_2^{(4)}] +[v_3^{(1)} , v_3^{(2)} , v_3^{(3)} , v_3^{(4)}]$

$[u_2^{(1)} , u_2^{(2)} , u_2^{(3)} , u_2^{(4)}] =[-10,-5,1,10]$

$[c_{24}^{(1)}, c_{24}^{(2)}, c_{24}^{(3)}, c_{24}^{(4)}]= [u_2^{(1)} , u_2^{(2)} , u_2^{(3)} , u_2^{(4)}] +[v_4^{(1)} , v_4^{(2)} , v_4^{(3)} , v_4^{(4)}]$

$[v_4^{(1)} , v_4^{(2)} , v_4^{(3)} , v_4^{(4)}]= [-9, 2, 10, 17]$

$[c_{11}^{(1)}, c_{11}^{(2)}, c_{11}^{(3)}, c_{11}^{(4)}]= [u_1^{(1)} , u_1^{(2)} , u_1^{(3)} , u_1^{(4)}] +[v_1^{(1)} , v_1^{(2)} , v_1^{(3)} , v_1^{(4)}]$

$[u_1^{(1)} , u_1^{(2)} , u_1^{(3)} , u_1^{(4)}] = [-13,-8,-3,4]$

We find, for each empty cell of the sum $[u_i^{(1)},u_i^{(2)},u_i^{(3)},u_i^{(4)}]$ and $[v_j^{(1)},v_j^{(2)},v_j^{(3)},v_j^{(4)}]$.

Next we findnet evaluation $[Z_{ij}^{(1)},Z_{ij}^{(2)},Z_{ij}^{(3)},Z_{ij}^{(4)}]$ is given by:

	FD1	FD2	FD3	FD4	Fuzzy Capacity
FO1	[-2,0,2,8] [-18,-4,10,24]	[-2,0,2,8] *[-18,-6,5,23]	[-2,0,2,8] *[-18,-6,5,23]	[-1,0,1,4] *[-22,-7,7,26]	[0,2,4,6]
FO2	[4,8,12,16] *[-17,-1,12,22]	[4,7,9,12] *[-18,-3,9,24]	[2,4,6,8] [-12,-2,8,18]	[1,3,5,7] [-23,-5,13,31]	[2,4,9,13]
FO3	[2,4,9,13] [-23,-7,9,25]	[0,6,8,10] [-12,-2,8,18]	[0,6,8,10] [-11,-3,5,13]	[4,7,9,12] *[-18,-3,9,24]	[2,4,6,8]
Fuzzy Demand	[1,3,5,7]	[0,2,4,6]	[1,3,5,7]	[1,3,5,7]	

Where U_i= $[u_i^{(1)},u_i^{(2)},u_i^{(3)},u_i^{(4)}]$, V_j= $[v_j^{(1)},v_j^{(2)},v_j^{(3)},v_j^{(4)}]$ and *$[Z_{ij}^{(1)},Z_{ij}^{(2)},Z_{ij}^{(3)},Z_{ij}^{(4)}]$ = $[c_{ij}^{(1)},c_{ij}^{(2)},c_{ij}^{(3)},c_{ij}^{(4)}]$ - $[u_i^{(1)},u_i^{(2)},u_i^{(3)},u_i^{(4)}]$ +$[v_j^{(1)},v_j^{(2)},v_j^{(3)},v_j^{(4)}]$

Since all $[Z_{ij}^{(1)},Z_{ij}^{(2)},Z_{ij}^{(3)},Z_{ij}^{(4)}]$>0 the solution is fuzzy optimal and unique.

Therefore the fuzzy optimal solution in terms of trapezoidal fuzzy numbers:

$[X_{11}^{(1)},X_{11}^{(2)},X_{11}^{(3)},X_{11}^{(4)}]$ = [-18,-4, 10, 24]

$[X_{23}^{(1)},X_{23}^{(2)},X_{23}^{(3)},X_{23}^{(4)}]$ = [-12,-2, 8, 18]

$[X_{24}^{(1)},X_{24}^{(2)},X_{24}^{(3)},X_{24}^{(4)}]$ = [-23,-5, 13, 31]

$[X_{31}^{(1)},X_{31}^{(2)},X_{31}^{(3)},X_{31}^{(4)}]$ = [-23,-7, 9, 25]

$[X_{32}^{(1)},X_{32}^{(2)},X_{32}^{(3)},X_{32}^{(4)}]$ =[-12,-2,8,18]

$[X_{33}^{(1)},X_{33}^{(2)},X_{33}^{(3)},X_{33}^{(4)}]$ =[-11,-3,5,13]

Hence, the total fuzzy transportation minimum cost is

$[Z^{(1)},Z^{(2)},Z^{(3)},Z^{(4)}]$ =[-2,0,2,8] [-18,-4,10,24]+ [2,4,6,8] [-12,-2,8,18]+ [1,3,5,7] [-23,-5,13,31]+ [2,4,9,13] [-23,-7,9,25]+ [0,6,8,10] [-12,-2,8,18]+ [0,6,8,10] [-11,-3,5,13]$[Z^{(1)},Z^{(2)},Z^{(3)},Z^{(4)}]$= [-930,-148, 318 ,1188]=107

6. RESULT AND DISCUSSION

Then we conclude that the optimal transportation cost obtained from this new method is less than the optimal transportation cost obtained from the already existing method. Since the number of allocations is reduced this saves time also.

7. CONCLUSION

In this paper, we have obtained an optimal solution for the fuzzy transportation problem of minimal cost using the fuzzy triangular membership function, the new algorithm for the fuzzy optimal solution to a fuzzy transportation problem with triangular fuzzy numbers, the new algorithm of zero termination method. The proposed method provides more options and this can serve an important tool in decision making problem.

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