

Cost Optimization of Supply Chain Distribution Model Using Genetic Algorithm

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Abstract. Supply chain is the enterprise network that working together to develop and distributing products to customers. After the products have been produce, they will sending to distributor, and then forward to retailer and finally arrived in customer. Consequently, the role of supply chains distibution are very important. Supply chain enable the product moving from the plant to customers that separated by distance. So it is needed a tools that can solving on supply chain problems in order to minimize distibution cost. In this research, the propose metodology is using genetic algorithm to get result the distribution cost that minimize. The distribution cost has been resulted from this algorithm will be compared with result from TORA. And then we will know if genetic algorithm can be able to solving distribution problems more than optimal.

Keywords: supply chain, genetic algorithm, cost optimation, supply chain distribution.

1 Introduction

Supply chain is a network of companies that work together to produce and deliver a product to the customer. Examples the raw materials that are deliver from the supplier to the plant. Therefore, the role of distribution and transportation networks is important. This distribution and transport network enables the product to move from the plant to consumer that limited by distance. To solving this conditions, distribution and transportation management will perform some basic functions, and the one of function is to determine the delivery route and the amount of shipping capacity so that it will minimize the total cost of distribution. On the issue of distribution there are two kinds of influential costs. The first is the cost variable, its cost increase along with the increase in the number of products that are transported from source to destination. And the second is a fixed charge or a fixed cost that is not dependent on the amount of products that are transported from the source to destination. Based on the problem of distribution that has been mentioned above it is necessary an application that can produce an optimal solution to solve the problem. Therefore, genetic algorithm is used to determine the most optimal distribution cost. This genetic algorithm [1][2][3][4][5] is aptly used for solving complex optimization problems and difficult to solve by conventional methods.

2 Distribution Problems

A distribution problem in supply chain discuss about how can a products deliver start from the plant to suppliers, and then supplier deliver to customer. The aims of distribution problem is to get the optimal cost, so looking for the lower or minimum cost distribution. The characteristic of distribution problems are [6] :

- The distribution problems have many of supply, source, or plant and demand.
- The quantity of product, it is the sum of product that will distributed from supply to demand
- The quantity of product must be suitable with quantity of demand

The distribution model usually can be describe using illustration in Fig. 1.

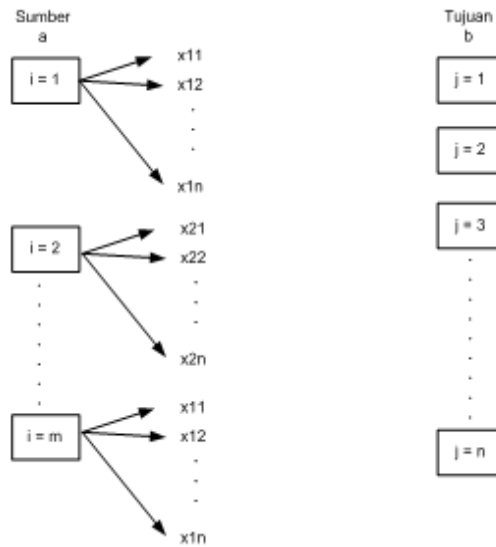


Fig. 1. Illustration Model of Distribution.

In the Fig.1 have many m supply and n demand, the figure can explained are :

- Each of supply have capacity (a_i).
- Each demand need some of product as much as b_j
- The sum of unit product that will deliver from supply to demand is X_{ij}
- Cost to deliver the unit product from supply to demand is C_{ij}

Beside on the model from Fig.1, so we can writing the formula of cost distribution is :

$$\text{Minimize } Z = \sum_{i=1}^m \sum_{j=1}^n C_{ij} X_{ij} \quad (1)$$

Where ,

$$\sum_{i=1}^n x_{ij} \leq a_i, \quad i = 1, 2, \dots, m \quad (2)$$

$$\sum_{i=1}^m x_{ij} \geq b_j, \quad j = 1, 2, \dots, n \quad (3)$$

$$X_{ij} \geq 0 \text{ for all } i \text{ and } j \quad (4)$$

In the equation 2 show the quantity of product that will deliver not more than the quantity of demand, and the equation 2 explain that the quantity of product that will deliver must be suitable with the demand.

2.1 Genetic Algorithm

Genetic algorithm is a technic that using selection mecanism [7]. Based on Darwin's theory of survival, GA have the fitness for optimal value. In the Fig.2 will be explained the work flow on genetic algorithm.

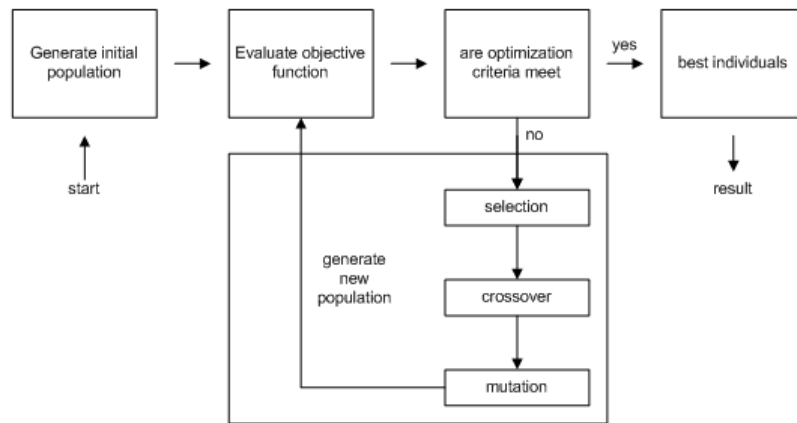


Fig. 2. The work flow of Genetic Algorithm.

In the 1st square on Fig.2, GA will be population cluster randomly. This population will be a candidate of the solution. Each candidate can be transformation with the biner form. The 2nd square, all candidate will evaluated using objective function and then produce the fitness value. In the 3th square, the population will be compare for get the optimal value. The 4th square is selection process, and next square is crossover, this process is making new individu form previous individu that have characteristics same.

3 Metodology

In this section will be explain about the architecture design of distribution problem and the steps in genetic algorithm.

3.1 Design of Distribution Problem

The distribution problem in this research will have two kind of cost. there are the variable cost and the fixed cost. The variable cost is conditional, depend on the quantity of product that will deliver. And the fixed charge have stable characteristic. It is never change although the quantity of product that will deliver grow up. The model of distribution problems [3][8] can be describe on Fig. 3.

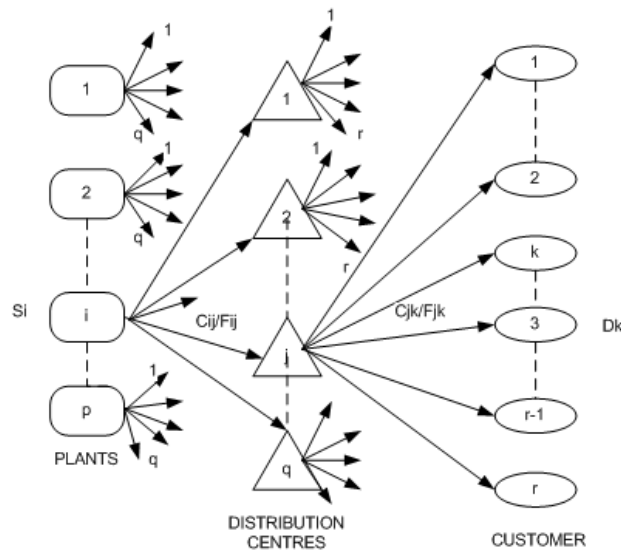


Fig. 3. Model Distribution Problem.

In the model have two kind of level, the first level is start from plant (supplier) to distribution center (warehouse). And the second level have start point from distribution center to customer. Each plant can deliver to any distribution center with cost is C_{ij} . the cost (C_{ij}) will sum with the fixed charge (F_{ij}). Each distribution center can deliver to any customer with transportation cost is C_{jk} and then it is sum with fixed charge (F_{jk}). The plant have some of capacity (S_i) dan then distribution center have value of capacity it is called D_k . The distribution problem in this research can calculate with mathematic model in equation 5.

$$\text{Minimize } Z = \sum_{i=1}^p \sum_{j=1}^q (C_{ij} X_{ij} + F_{ij} \delta_{ij}) + (C_{jk} X_{jk} + F_{jk} \delta_{jk}) \quad (5)$$

Where :

$$\sum_{j=1}^q X_{ij} \leq S_i \quad (\forall i, i = 1 \text{ to } p) \quad (6)$$

$$\sum_{j=1}^q X_{jk} = D_k \quad (\forall k, k = 1 \text{ to } r) \quad (7)$$

$$X_{ij} \geq 0, \text{ and integer} \quad (8)$$

$$X_{jk} \geq 0, \text{ and integer} \quad (9)$$

Table 1. Notation or Input Variable.

No	Variable/ Notation	Information
1.	P	Number of <i>plant</i>
2.	Q	Number of <i>distribution center</i>
3.	R	Number of <i>customer</i>
4.	S_i	The capacity of each plant
5.	D_k	Number of demand for each customer
6.	C_{ij}	Cost to deliver form <i>plant i</i> to <i>distribution center j</i>
7.	F_{ij}	Fixed charge from <i>plant i</i> to <i>distribution center j</i>
8.	C_{jk}	Cost to deliver from <i>distribution center j</i> to <i>customer k</i>
9.	F_{jk}	Fixed charge form <i>distribution center j</i> to <i>customer k</i>
10.	JumlahGenerasi	Number of generation
11.	JumlahKrom	Number of chromosome
12.	p_cross	Probability of crossover
13.	p_mut	Probability of mutation

3.2 The Work Flow of Algorithm

In this section, will explained about the architecture desain of genetic algorithm to solve distribution problem. The steps in this algorithm are :

- a. Input module
in this step will using data input on Table 1. In this table will explain any variable that used to calculate Z value on equation 5.
- b. Initialisation chromosome
In initialisation step is process to establish a chromosome. It is a matrix of order $j * k$, where j is distribution centre $1... q$ and k is customer $1...r$.
- c. Evaluation chromosome
Calculate Z value with equation 5
- d. Sorting function
After we get the fitness value, next the fitness values is called the best fitness. It is will compared with the best fitness previously.
- e. Selection function
The aims of process selection is to keep the chromosome that own best fitness value, and will eliminated the chromosome that have bad fitness value. the fitness value on this step will converted using equation 10.

$$new_fit(c) = e^{v*fit(c)} \quad (10)$$

- f. Crossover function
Crossover is a process to get a old chromosome, a chromosome that will crossover until produce the offspring.
- g. Mutation function
In this step, mutation process have a main parameter, it is probabilitas mutation (p_mut). This value will compare with R_mut that obtained randomly. If $R_mut < p_mut$ so the mutation process will be execute.
- h. Output
In the end step will showed the fitness value of chromosome that have optimal value. it's minimize Z .

4 Result and Analysis

The result in this research will analyzed and showed in Tabel 2. The data result produced using 15 data testing. This data is the cost distribution from plant to customer through distribution center. After that, the next testing do with TORA software. This aims is we can know that the result which execute with GA is more accurate, or closed if calculate with TORA.

Table 2. Percentage of Test Result.

No	Data	Solution		Different value	Percentage (%)
		TORA	AG		
1	Data 1	237763.5	237750	13.5	0.005
2	Data 2	157055	157050	5	0.003
3	Data 3	161711.4	161880	168.6	0.104
4	Data 4	56022.5	56638	615.5	1.086
5	Data 5	64741.85	64743	1.15	0.001
6	Data 6	253413	254530	1117	0.438
7	Data 7	74652	74738	86	0.115
8	Data 8	73199	73195	4	0.005
9	Data 9	45467.3	47140	1672.7	3.548
10	Data 10	168826	169825	999	0.588
11	Data 11	52591.5	53997	1405.5	2.602
12	Data 12	132893.6	132890	3.6	0.002
13	Data 13	93105	97707	4602	4.71
14	Data 14	279513.5	279680	166.5	0.059
15	Data 15	71455.5	75293	3837.5	5.096

The data in Table 2. describe that the result is accurate. The data from calculate using genetic algorithm with parameter such as : number of chromosome = 10, crossover probability = 0.3, mutasion probability = 0.5 and number of generation = $pq+qr$. According to this scenario the result using TORA on Data 1 is = 237763.5 and using algorithm is = 237750. The data 1 data 2, data 8, data 9, and data 11 show that using genetic algorithm, the value of cost distribution more than minimize if using TORA.

5 Conclusion

The conclusion of this research is genetic algorithm can used to solve distribution problems. This algorithm is capable to get optimal solution, closed with TORA. This corresponds to the average percentage of difference value is 1.22%. The performance of genetic algorithm is associated with any parameter such as : number of chromosome, crossover probablity and mutation probability. The number of chromosome can associated, if the number is too poor so the chromosome will reach convergence soon and the result value often at local optimal position. And the opposite, the number of chromosome is more so the calculation is more complex and the time computation is longer.

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