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Optimal Transportation Cost Using Genetic Algorithm

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Abstract—*This paper deals with the minimization of transportation cost that includes different types of costs like ordering cost, holding cost, labour cost, raw material transporting cost to manufacturing firm and several other costs. All these costs are incorporated in the total cost, and then we optimize (minimize) the total cost, which is our fitness function using genetic algorithm (GA). It also ensures the minimum time to be taken in transportation of either raw materials to manufacturing firm or final delivery of finished goods to the customer. This framework of genetic algorithm gives us a number of advantages like it provides us several iterations until it finds out the final solution (optimum fitness function).*

Keywords*: Genetic algorithm, Transportation problem, Optimum fitness function, Manufacturing firm.*

1. INTRODUCTION

The transportation problem (TP) comes under linear programming problem which is a mathematical technique for maximizing or minimizing a linear function with several variables such as output or cost (Hillier and Lieberman, 1995). It is one of the sub-classes of linear programming problems in which our objective is to transport various products (cargo) either as raw materials or finished goods to different destinations such as manufacturing firm, distributor, retailer or customer in such a way that the total transportation cost can be minimized. Here we have considered the minimization of transportation cost by applying genetic algorithm for a four-stage supply chain. The transportation plays an important part in both downstream and upstream of the supply chain, because in both cases delivery of cargo should be in time for continuous production without any hurdle. Finding level of inventory and forecasting the availability of products finally depend on the transportation, and determines the transportation costs. The transportation cost incurred varies with the different modes of transportation chosen like by air, by ship or by truck depending upon the size of cargo, delivery time and also on the emergency of the demand of the product. Hence, the particular mode chosen depends on the characteristics of the mode and the company's needs.

2. LITERATURE REVIEW

Today's companies are trying hard to give their best in implementing new technologies and methodologies for improving their supply chain as it play an important role in the growth of any organization (Cai et al., 2009). For improving the supply chain quality, we need to reduce the lead time, ensure fast delivery, incorporate automation, improve quality of products, make on- time delivery and minimize the cost. Many of these factors are related to transportation. Hence, the present paper focuses on the minimization of the transportation cost using a technique called genetic algorithm (GA). In the recent time GA has received a significant attention to find the optimalsolution which gives the best fitness function in minimum time. (Sivanandam and Deepa, 2008). In areas of operations research and computer science, genetic algorithm is categorized as a high level procedure which is based on the natural selection by biological evolutions such as reproduction, mutation, recombination and selection (Goldberg, 2002). This evolution usually starts from the selection of individuals from the population and then doing some changes like crossover and mutation to produce offspring. It is an iterative process, where the population or the new offspring produced in each iteration is termed as generation. In each iteration, the fitness of offspring is evaluated until we get the best fitness function. Hence, we need to optimize the fitness function, which is the transportation cost in our case that has to be minimized. Some basic logistics trends which are helpful in managing supply chain include transportation trends and customer relationship management (Christopher, 1992). Transportation trends include trade-off decision between cost and timing of delivery/customer services via trucks, rail, water and air. On the other hand, customer relationship management deals with strategies to ensure deliveries, resolve complaint, improve communication and determine service requirements. The main objective of any supply chain is to maximize the overall value created, as the value is correlated to supply chain profitability, defined as the difference between the revenue generated from the customer and the overall cost across the supply chain

(Hicks, 1999). Organizations either have need to buy the components from the supplier to build a supply chain network, which include location of the supplier from the manufacturing firm, transportation facility, inventory facility as well as costs and forecasting through which the products and services are managed and ultimately delivered. Locations may be manufacturing firms, inventory storage, warehouses, distribution centers, ports, the suppliers, the transport carrier, a third-party or second party logistics provider, a retailer and finally the end customer (Chopra and Meindl, 2007). The modes of transportation include different types of trucks, train, ship or by air, two wheeler or four wheeler transportation for the units or raw materials movement within the organization, container ships or cargo planes. The size of the container is also specified so that the space for the cargo can be fully occupied without any wastage.

3. METHODOLOGY

The optimization model used in this paper is genetic algorithm (GA), which is used to determine the transportation schedule that will minimize the total transportation cost and will satisfy the requirement of items at the depots. Here the fitness function is calculated after every crossover and mutation and several iterations are performed till we get the best fitness function with lowest transportation costs. The genetic algorithm is able to solve the problem by detailing the following steps:

- Declare parameters
- Coding / decoding system
- Initial population
- Reproduction system
- Crossover
- Mutation
- Stopping criteria

While formulating the mathematical model of the transportation problem using genetic algorithm, the following terminologies are used for the production of one product in monetary unit (MU) in the analysis of problem

- R_T: Total cost
- R_{pt}: Final cost-Risk cost
- R_{rm}: Raw material cost
- R_o: Cost associated with ordering raw materials
- R_c: Cost associated with carrying raw materials
- R_r: Risk cost
- R_{tr}: Transportation cost
- R_p: Purchasing cost of raw materials
- R_u: Service cost of the product
- R_d: Duties cost for providing raw material from an external supplier
- Rtp_i: For providing raw material *i* from an external supplier *i* (Transfer cost)
- O: Ordered raw materials origin
- D:Required raw materials destination
- M_i: Mode for transporting raw material i to its customer
- N_M: Number of transportation modes required
- S_{ej}: External supplier j for raw materials
- S_{LB}: Raw material local back up supplier i
- IF: Indicator function for duty with a value 1 or 0.1 if the supplier and the production facilities are in the same country, and 0 otherwise.
- LR: Likelihood of occurrence for risk
- IR: Impact of risk occurrence
- N_o: Number of operations
- N_P: Number of parts
- N_{SE} : Number of raw material external supplier j
- R_{ou}: Cost associated with ordering raw material for the final product
- R_{uc}: Cost associated with carrying raw materials for the final product
- R_{umi}: Unit cost of raw material
- $\%D_{rm}$: Every day demand (raw materials).
- h: Operation time (hr)
- R_l: Labor cost (MU/hr)
- I_{NF}: Inventory factor for storing raw materials in the warehouse
- O_F: Ordering factor for taking each order from the supplier
- %UT: Utilities cost of the final product
- R_p: Cost subjected for providing raw material *i* from an external supplier *j*
- L_T: Time taken between ordering and receiving the placed items
- T_{oj}, *d*, *m*: Cost required transporting material from origin *o* to destination *d*.

- %V: Volume of raw material which is to be transported to the customer
- D_r:Duty rate (%)
- $\%T_{rs}$: Total risk

The solution of the transportation problem using genetic algorithm utilizes the following concepts. The purpose of this model is to minimize the total costs (R_T), including R_o, R_c, R_p, R_{tr}, R_d, R_{tp}, R_u and R_r using genetic algorithm. The total cost can be calculated as follows:

$$R_T = R_{pt} + R_r \quad (1)$$

$$R_{PT} = R_o + R_c + R_p + R_d + R_{tp} + R_u \quad (2)$$

R_T can be calculated as represented by equation (3):

$$R_T = \sum_{j=1}^{N_{SE}} R_{OUj} \times O_F + \sum_{i=1}^{N_p}\sum_{j=1}^{N_{SE}} (R_{UCi})_j \times \%D_{rm} \times \left(CT_J + I_{NF}\right) + \sum_{i=1}^{N_P}\sum_{j=1}^{N_{SE}} (R_{umi})_{\cdot j} + \sum_{j=1}^{N_{SE}}\sum_{IR=1}^{N_M}\sum_{i=1}^{N_p} T_{SLB_J},d,m \times t_{mIR} \times \%V_i + \sum_{i=1}^{N_p}\sum_{j=1}^{N_{SE}} R_{UP_i}\left(1 - IF_j\right) \times D_j + \sum_{j=1}^{N_{SE}}\sum_{i=1}^{N_p} R_{P_j} \times R_{UP_i} + \sum_{i=1}^{N_p} R_{l_i} \times h_i + \sum_{i=1}^{N_p} \%UT \times R_{rm_i} + \sum_{i=1}^{N_p}\sum_{k=1}^{LR_k} \frac{LH_k \times IR_k}{MAX(LH_k \times IR_k)} \times R_{pt_j} \quad (3)$$

This mathematical model consists of several external suppliers who are responsible for supplying raw materials to the manufacturing firm, which produces the final product and then it goes to the distributor and retailer and finally to the customer. Initial population is defined as the iterations of a number of solutions, the population is usually initialized randomly.GA parameters are population size (N), mutation rate (M_R), crossover rate (C_R) and maximum iteration (termination of GA) (I_{max}). Our main aim is to minimize the fitness function which is calculated by converting the total cost given by equation (3) to the fitness function, calculated as follows:

$$F = \frac{100}{(R_T+1)} \quad (4)$$

For each iteration, new offsprings are generated by applying crossover and mutation like crossover generates $N\times C_R$ offspring and by mutation, we get $N\times M_R$ offspring. The input GA parameters are tabulated in the following table.

Parameters	Rate
N	500
M_R	0.3
C_R	0.9
I_{max}	6000

4. CONCLUSION

In the present paper, we have proposed a mathematical model of a transportation problem that minimizes cost by genetic algorithm (GA). The optimal solution of the transportation problem not only gives the minimum cost but also gives the minimum time of transportation. Various costs included costs involved in reaching the raw materials from the supplier (origin) to the manufacturing firm and finally to the customers(destination).The major advantage of using these algorithms is that even though the numbers of iterations are very high, an optimal solution is obtained within less time (few minutes). Hence, the results obtained offer a near minimum cost with a best fitness function.

REFERENCES

[1] Cai, J., Liu, X.,Xiao, Z. and Liu, J. 2009. Improving Supply Chain Performance Management: A SystematicApproach to Analyzing Iterative KPI Accomplishment.

[2] Christopher, M. 1992.Logistics and Supply Chain Management, Fourth Edition, PearsonEducation, Singapore.

[3] Goldberg, D. E. 2002. Genetic Algorithms: in Search, Optimization and Machine Learning. Pearson Education, Singapore.

[4] Hicks, D. A. 1999. Four Step Methodology for using Simulation and Optimization Technologies in Strategic Supply Chain Planning, Proceedings of the 1999 Winter Simulation Conference, pp.1212-1220.

[5] Hillier, F. S. and Lieberman, G. J. 1995. Introduction to Operations Research, Sixth Edition, McGraw-Hill Inc., New York.

[6] Sivanandam, S. and Deepa, S. 2008. Introduction to Genetic Algorithms. Springer Berlin Heidelberg,New York.

[7] Chopra, Sunil and Meindl, Peter. 2001. Supply Chain Management: Strategy, Planning, and Operation, Pearson Education, Singapore.