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# Vehicle Routing Algorithm based on Matrix

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## ABSTRACT

Effective supply chain strategies for creating competitiveness revolve around the on-time delivery of quality goods and services, at a reasonable cost. This balance between time constraints and profit can be achieved if and only if distribution system is efficient. The efficiency of distribution system can be increased if the vehicle is routed efficiently through network of bunch of customer scattered over area so as to facilitate the scheme at low operational costs and short transporting time as possible also taking care of customer satisfaction as well. This article attempts to put forth the issues supporting importance of vehicle routing in SCM and presents an algorithm for vehicle routing problem. A realistic case study based on road network of city Yavatmal (India) is also presented.

**Keywords :** SCM, Distribution System

## I. INTRODUCTION

An essential element of any logistical system is the allocation and routing of vehicles for the purpose of collecting and delivering goods and services on a regular basis. Common examples include newspaper delivery, school bus routing, municipal waste collection, fuel oil delivery and truck dispatching in a number of industries. A key element of many distribution systems is the routing and scheduling of vehicles through a set of customer requiring service[4]. The vehicle routing problem involves the design of set of minimum cost vehicle routes, originating and terminating at central distribution center for fleet of vehicles that services a set of customer with known demands. Each customer is serviced once and all the customer must be assigned to vehicles without exceeding the vehicle capacities [4]

The problem of distribution from various warehouses to the retailer can be modeled as if every distribution center has a known number of retailers attached to it, to whom it has to supply the goods[2]. The system may involve a single depot or multiple depots; the objectives may be aimed at cost minimization (distribution costs, vehicle or depot acquisition costs) or service improvement (increasing distribution capacities, reducing distribution time and related network design issues).[2]

Constraints may be imposed upon:[2]

(a) The depots (numbers, possible locations, and production capabilities),

(b) The vehicle fleet (types and numbers of vehicles, and vehicle capacities),

(c) The delivery points (demand requirements, service constraints on delivery 'time and order splitting),

(d) The routing structure (maximum route time or route distance, link capacities, and preferences for radial routes or routes with points closer together),

(e) Operator scheduling and assignments (union regulations),

(f) System dynamics (inventory holdings, and distribution or acquisition lag times)

During past few years increasing trade of just in time(JIT), high level of business competition, increasing number of customer demands are forcing

the organization to think and find a solution for managing their dispatching activities properly with due consideration to in time delivery while taking care of their profit as well.

In general any delivery boy sequence his trip on the basis of his years of experience or just his casual judgment .This method is reliable in small cities or when the numbers of customers are located nearer to each other. But in case reverse case i.e. metro cities where customers are located far away from each other and there are many hurdles in journey such as traffic problems the experience and manual judgment makes the journey time consuming and some what lengthier. Both these effects is not at all desirable because of increasing trade of in time delivery. Lengthier trip would affect the transportation cost and hence the profit.

In order to solve this purpose of routing and scheduling it was felt and rather was an imperative to have some method or technique to sequence properly the delivery orders so as to take care of in time delivery to customer on the same ground meeting the business objectives as well.

Hence in this paper we have presenting a simulation experiment/program for routing and scheduling. To make this task mare realistic/ authentic the data required for calculation is taken from local firm 'XYZ bakery Yavatmal'. After making the analysis of the methodology they were adopting following problem were diagnosed.

- excessive delay in delivering goods
- distances traveled was also high

To solve this problem simulation program is used and result i.e. the order in which they should serve the customer is determined. This paper is structured in two parts. First throwing the light on importance of vehicle routing. And in second a simulation programme for vehicle routing.

NEED FOR PROPER VEHICLE ROUTING

To compete successfully in today's marketplace, organizations need concurrently to manage effectively and efficiently the activities of design, manufacturing, distribution, service to customer. The concept supply chain management is evolved with the same objective to manage these business operations effectively. There are number of definitions supply chain management coated by various authors. Some of those are summarized in table-1[3]

| Author | Definitions |
|---|---|
| Ellram and Cooper (1990) | SCM is an integrative philosophy to manage the total flow of distribution channel from supplier to ultimate user |
| Sengupta and Turnbull ( 1996) | SCM is the process of effectively managing the flow of materials and finished goods from vendors customers using manufacturing facilities and warehouses as intermediate stops |
| Handfield and Nichols(1999) | SCM is the integration of these and activities (activities associated with flow and transformation of goods from raw materials stage, through to the end user as well as associate information flows) through improve supply chain relationships to achieve sustainable competitive advantage |

As clear from above that SCM is all about flows viz product, information, finance. Hence the efficient distribution system acts as lubricant to smooth this flows.

Time is the primary competitive motive of business. This does not mean that other motives such as cost, quality, and service can be ignored. In fact, these are prerequisites to sustain competitiveness. But the winning factor is provided by time-based competition, which becomes the highest priority to gain responsiveness and flexibility. There is no escaping from the fact that the customer in today's marketplace is more demanding, not just of product quality, but also of service. In time delivery of quality product guarantees better service. Apart from this business has to take care of profit as well. Hence to achieve both these objectives distribution system should be as efficient as possible.

## II. ALGORITHM FOR VEHICLE ROUTING

The most important factor related to transportation in a supply chain is routing and scheduling of deliveries. We developed a generalized program which gives the effective routing and scheduling of deliveries to the customer. It decides that which customers to be visited by a particular vehicle and the sequence in which they will be visited so that transportation cost will be minimized. The algorithm uses following computational procedures to support final decision.

The variables in the program are number of customers, capacity of vehicle, x & y coordinate and order size of each customer. By considering these variables our first aim is to decide which customers are to be visited by a particular vehicle that is to form the group of the customers for each vehicle. It requires the computation of the distance matrix & saving matrix. This method is known as saving matrix method.

SAVING MATRIX METHOD[1]:

It basically consist of following four steps as discussed below.

1)calculate the distance matrix

2)calculate the savings matrix

3)grouping customers

3)sequencing the customer along the route.

Above steps can be explained much clearly with the help of example.

Consider that distribution manager has received following set of orders from 6 different customers spread in city area on a particular day. The location of distribution center (DC), each customer, and order size (A) from each customer is shown in table2.

| | X coordinate | Y coordinate | Order size (A) |
|---|---|---|---|
| Warehouse | 0 | 0 | |
| Customer1 | 9 | 12 | 50 |
| Customer2 | 17 | -2 | 38 |
| Customer3 | 20 | -7 | 43 |
| Customer4 | 15 | 3 | 40 |
| Customer5 | 20 | 0 | 30 |
| Customer6 | 6 | 5 | 29 |

Table2:customer location and demands.

The manager has two four trucks each having a capacity of carrying 120 units.

CALCULATE THE DISTANCE MATRIX:

The distance matrix identifies the distance between every pair of location to be visited. The distance *Dist*(a,b) on a grid between point (a) with coordinate (Xa,Ya) and point (b) with coordinates (Xb,Yb) can be calculated as[1]

"$Dist(a,b)=[(Xa-Xb)^2+(Ya-Yb)^2]^{1/2}$"

The calculated result is as shown in table3.

| | DC | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| C1 | 15 | 0 | | | | | |
| C2 | 17 | 16 | 0 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C3 | 21 | 22 | 6 | 0 | | | |
| C4 | 15 | 11 | 5 | 11 | 0 | | |
| C5 | 20 | 16 | 4 | 7 | 6 | 0 | |
| C6 | 8 | 8 | 13 | 18 | 9 | 13 | 0 |

Table3:distance matrix.

CALCULATE THE SAVING MATRIX:

Saving matrix represent the saving that occurs on considering two customer on single track. Thus S(a,b) is the distance saved if trips DC-customer a-DC and DC-customer b-DC is combined to single trip as DC-customer a-customer b-DC. This saving can be calculated by formula,[1]

"S(a,b)=dist(DC,a)+dist(DC,b)-dist(a,b)"

The calculated result is shown in table4.

| | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| C1 | 0 | | | | | |
| C2 | 16 | 0 | | | | |
| C3 | 14 | 32 | 0 | | | |
| C4 | 19 | 27 | 25 | 0 | | |
| C5 | 19 | 33 | 34 | 29 | 0 | |
| C6 | 15 | 12 | 11 | 14 | 15 | 0 |

Table4:saving matrix.

GROUPING CUSTOMERS:

While assigning customer to route the objective is to maximize the savings. An iterative procedure is used to make this assignment. Initially each customer is assigned to separate route. Two routes combined into a feasible route with highest saving by taking into account the total deliveries across the routes do not exceed the vehicle capacity [1].

In our example highest saving is 34 by combining customer3 and customer5. this route is feasible because total load is 43+30=73,which is below 120. next highest saving is 33 by combining customer2 with customer5. since customer is already in route only customer2 will be added and is feasible again because it will increase load to 111 which well below 120. further combination to this route is not possible because of capacity constraints.

Continuing with this iterative procedure customer is grouped as {3,5,2} and {4,1,6}.

SEQUENCING THE CUSTOER ALONG THE ROUTE:

Our next aim is sequencing of customer within route to minimize distance the vehicle must travel.

In given vehicle trip (consisting of DC only) for each remaining customer evaluate the minimum increase in length if this customer is inserted at a suitable point in trip. It is accomplished by inserting customer with largest minimum increase to obtain new trip. This process is also referred as farthest insert because farthest customer is inserted first. the process is continued until all remaining customer to be visited by vehicle are included in trip[1].

In present example in order to sequence customer 3,5,2. the initial trip consist of only DC with length 0. adding 3 will make it42, adding 5 will make it40 and adding 2 will make 34. thus by using farthest insert customer 3 is added to route.

At next step inserting customer 5 increases the length of trip to 48 and that of customer 2 will make it44.Thus feasible is to added customer 5 to obtain the new trip as DC-3-5-DC. Still customer 2 remaining. The minimum cost of insertion for customer 2 is DC-3-5-2-DC with length equal to 49.(other combination such as DC-2-3-5-DC, DC-3-2-5-DC, gives length 50 and 51 respectively). Thus vehicle should be routed as DC-3-5-2-DC.and total distance for this trip is 49.

## III. RESULT FOR CASE STUDY:

In order to prove proficiency of programme it was implemented for one of local bakery in Yavatmal city of India, dispatching their products to various outlets located through the city. And following results were obtained which shown graphically.

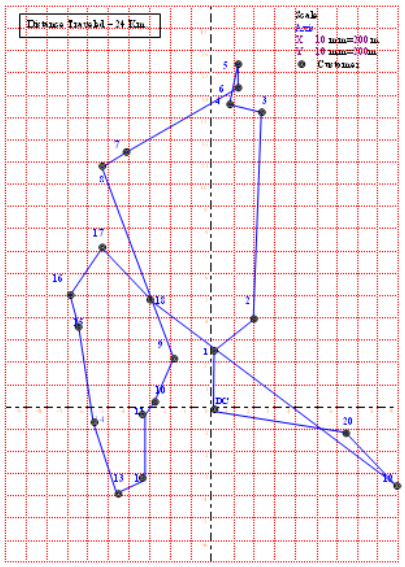

Figure1: adopted route sheet for XYZ bakery ltd. Yavatmal.

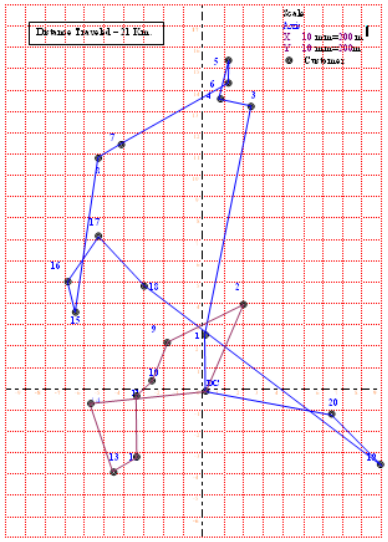

Figure2:propsed route sheet for for XYZ bakery ltd. Yavatmal.

## IV. CONCLUSION

In this paper transportation problem is analyzed by the program that is built for optimization of cost and time. One of the most important parameter in industry is reducing time for transportation. It is not possible to think about transportation excluding the one of the most parameter that is assignment of vehicles. Assignment is a term related to the transportation in which the vehicle is assigned to the cluster of customers. the assignment of vehicle is consider to be Herculean task to manager. This can be simplified by developing a program. The computer assist the operator to solve the complication in the transportation problem with the help of program developed in the computer language such as C, C++, java, etc.

Thus, the program has been developed to ease the process of decision making to solve the problem of transportation. This program is used to obtain the optimum path, sequence of vehicle, group of customer, minimum distance traveled by vehicle by using the theory suggested by sunilChopda & Peter Meindl. The result is obtained in the form of group of customer to whom the goods to be delivered. These groups of customers are assigned on the basis of order size (the order of goods is given by customer), the distance of customers from the warehouse & also the distance between customers. If the parameter such as number of customer, order size, position of customer (in term of horizontal & vertical distances) & vehicle number are known then the result is shown in the form of distance matrix, saving matrix, group of customer assign to each vehicle & distance traveled by each vehicle.

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