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Stochastic optimization of multi-capacitated vehicle routing problem with pickup and delivery using saving matrix algorithm

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Abstract

The Multi-Capacitated Problem is an optimization problem. To reduce the overall distance, the optimization problem seeks out vehicle routes that connect every customer to a storage facility. This article uses a saving matrix approach to propose an extended Vehicle Routing Problem that considers a stochastic environment and multiple capacitors. Stochastic customers are an essential element of the problem. A computational analysis also supports the suggested approach to obtain the best route.

Subject Classification: *Applications of Graph Theory (05C90), Applications of Graph Theory to Circuits and Networks (94C15), Distributions and Stochastic Processes (97K60).*

Keywords: *Vehicle routing problem, Stochastic optimization, Integer programming, Saving matrix approach, Route, Distance.*

1. Introduction

The Vehicle Routing Problem (VRP) is a helpful and well-researched issue, including optimization problems. VRPs are generally regarded as a problem with static routing. This study concentrates on the problem of multi-capacitated vehicle routing with minimum pickup and delivery time (MCVRPPDMT). In the current market, every customer wants to get their online purchases delivered at a minimum cost and in the shortest possible time [6],[14]. One of the ways companies go about doing this is through optimization of their operations. It consists of optimizing the sum of the total cost of the scheduled possible paths and expected failures [9][12].

Stochastic Vehicle Routing Problems (SVRP)

Since Dantzig and Ramser first introduced this broad class of optimization challenges in a practical setting, VRPs have been the subject of many research studies. Then, collectively, the operations research community has made a great effort to solve these issues effectively, developing precise and heuristic methods. Based on these expressions, we find upper and lower boundaries for the PVRP and VRP re- optimization strategy, in which we find the optimal path at every instance. A conceptual modulation (Birge and Louveaux 1997) is shown by:

$$\min \Sigma_x f(x) + E(Q(x, \S)] \text{ s.t. } x \in X$$

Here *'x'* denotes the decisions of the first phase that must be initially taken before that information exists. These are some decisions associated with routing in most formulations. The f (.) function assesses the objective function that is the part of the decisions. *'n'* represents the non-discrete variables that make the issue probabilistic.

2. Literature Background

VRP is being experienced by UD. XYZ which causes cost overruns. The authors have provided saving matrix with a dynamic program approach, nearest neighbor, and nearest insertion to obtain the product distribution routes including minimize distribution costs at UD. XYZ [1]. The Authors have discussed the problem which is similar to VRP in that it goals to obtain the optimal distribution route while seeing future public demand forecasts [2],[9]. Saving matrix method (SMM) distribution path have reduced 3 routes of U-shape Ready Mix Concrete and 2 routes for O-shape [4],[7],[15]. Sitek P. and Wikarek J. [12] have presented the model of capacitated VRP pick and delivery with implementation using a hybrid approach. This paper is an extension form for the pick-up and delivery problem of the trained VRP. The paper is known as Capacitated Vehicle Routing Problem Pick and Delivery (CVRPPD). Nepomuceno N. et al. [11] have suggested a rapid randomized algorithm using the nearest neighbor (NN) strategy to address VRPSPD expansions in which the vehicle fleet is heterogeneous. The paper aims to minimize the total fixed vehicle and random transport costs and introduce a randomized algorithm based on the nearest neighbor. We proposed a quick algorithm in this paper that creates alternatives to choose the next client to be traversed by probabilistic alternation: a given client order or the NN strategy. Artikis, P. T., & Artikis, C. T. [13] have used two stochastic integrals. Rizwanullah M. and Nilofer M. [10] have introduced the Optimization of VRP by Using Saving Matrix Approach. The authors have taken an example of the dominos company that delivers to customers with minimum cost and time almost products. The paper proposed the saving matrix approach for each vehicle to find the best possible optimal route with the shortest distance and time. Hayawi, H. A. et al. [5] have presented classical and logic diagnosis approaches. Rannona, K. et al. [8] have provided a new generalized Exponentiated odd Exponential Half Logistic-G Power Series (EOEHL-GPS) class of distributions.

3. Problem Description Including Mathematical Model

DealShare company is an unbelievably disruptive model of social e-commerce aimed at reinventing retail for the next billion generations to generation. The pick-up and delivery of products at the minimum waiting time is, therefore, the most critical issue for the company. This paper discusses the DealShare company that supplies customers in Jaipur with almost goods with minimum time and cost. Headquartered in Bangalore,

DealShare, a B2C hyperlocal e-retail business, was established on 5th September 2018. The company has 100 vehicles used in the minimum time to pick up and deliver the products to their homes. Each vehicle has a different capacity that is finite. A reasonable way to enforce this restriction is to require that vehicle capacity is not exceeded by the expected demand for the route. DealShare is currently operational in Jaipur, Kota, Ajmer, Sikar, Ahmedabad, Surat, Vadodara, Jodhpur, Bikaner, Sawai Madhopur, and many more cities to come. Given a network with a specific weight value, let us assume that the vertices are *{1, 2, n}*, where node *1* represents the source point of the DealShare company and set *V = {2, 3, n}* indicates the collections of customer's locations. The traveled length *d (i, j)* is considered to be symmetric, and they fulfill this inequality:

$$d(i, j) \leq d(i, k) + d(k, j)$$

4. Methodology

First, we find the distance between two various cities from given set of cities and arrange these values in distance matrix. Second, obtain the saving values of each pair of all given places. The SMM will be used to obtain the delivery route for the distribution activity of goods to the consumer.

These some steps are:

1. distance matrix
2. savings Matrix
3. Rank savings

5. Solution Process

In this work, we have used different number of Vehicles which have a certain Capacity as shown Table 1 (Some Vehicles with Capacities) and Table 2 (Coordinates of all given destinations with demands) shows the coordinates of all 12 destinations .

Table 1

Some Vehicles with Capacities

S. No.	Name of the vehicle	The capacity of each vehicle	No. of the vehicle
1.	Pick-up	1500	22

Contd...

2.	Cargo Truck	2000	08
3.	TATA-407	1800	25
4.	Ven	1000	14
5.	Tempo	1600	31
			Total = 100

Table 2

Coordinates of all given destinations with demands

S. No.	Name of the Place	X Coordinates	Y Coordinates	Demand of Each Place
1.	Jagatpura	00	00	000
2.	Chomu Puliya	03	04	308
3.	Jhotwara	07	10	560
4.	Heerapura	14	21	480
5.	Mansarover	-10	15	345
6.	Murlipura	13	-11	330
7.	Choura Rasta	-04	-09	750
8.	Malviya Nagar	-16	07	240
9.	Raj Mandir	12	06	390
10.	Gourav Tower	-11	17	670
11.	WTP	-11	16	970
12.	Gurjar ki thadi	-12	-13	830

5.1 *Identify distance matrix*

The matrix for the 12 delivery centers is founded by eqn.1, as shown in Table 3 (Distance Matrix). The first stage in determining the best distribution path should be to get the company's warehouse position and location across the customers' businesses. The business is not used separately, so the warehouse (Dealshare) location is the company itself's place [3]. Clients in this study were used as a sample, amounting to 12 consumers. The distance between two several places A ($X1$, $Y1$) and B ($X2$, $Y2$), to be evaluated by the general distance formula:

$$D\,(A, B) = \sqrt{(X1 - X2)^2 + (Y1 - Y2)^2} \quad \ldots (1)$$

Here are a few values of possible traveled length (1 to 12) were calculated by the general distance formula above:

Table 3

Distance Matrix

	Jagatpura 1	Chom Puliya 2	Jhotwara 3	Heera-pura 4	Mansa rover 5	Murli-pura 6	Choura Rasta 7	Malviya Nagar 8	Raj Mandir 9	Gourav Tower 10	WTP 11	Gurjar ki thadi 12
Jagatpura1	00											
ChomuPuliya2	05	00										
Jhotwara3	12.20	7.31	00									
Heerapura4	25.23	20.24	13.03	00								
Mansarover5	18.02	17.02	17.72	24.73	00							
Murlipura6	17.02	18.02	21.84	32.01	34.71	00						
ChouraRasta7	9.84	14.76	21.95	41.03	24.73	17.11	00					
MalviyaNagar8	17.46	19.23	23.19	33.10	10	34.13	20	00				
Raj Mandir9	13.41	9.21	6.40	15.13	23.76	17.02	21.93	28.01	00			
GouravTower10	20.24	19.10	18.38	25.31	2.23	36.87	26.92	11.18	25.49	00		
WTP11	19.41	18.43	18.02	25.49	1.41	36.12	25.96	10.29	25.07	1	00	
Gurjar ki thadi12	17.69	22.67	29.83	42.80	28.07	25.07	8.94	20.39	30.61	30.01	29.01	00

5.2 *Early Route*

Of the ten companies, there have been transporting facilities in the form of 100 vehicles classified into five vehicles, such as Pick-up, Ven, Cargo Truck, Tempo, etc. Each conveyance has a different capacity in which the TATA-407 has a capability of 2800 Kg. The initial path of the company is 11 routes. The initial path for the company is depot-client-depot. The path length data on each path is following:

The Table 4 (Initial and distance route of Dealshare Company) is provided 11 initial routes of this transportation problem.

Table 4

Initial and distance route of Dealshare Company

S. No.	Consumer	Distance	S.No.	Consumer	Distance
1.	1-2-1	10	**7.**	1-8-1	34.92
2.	1-3-1	24.40	**8.**	1-9-1	26.82
3.	1-4-1	50.46	**9.**	1-10-1	40.48
4.	1-5-1	36.04	**10**	1-11-1	38.82
5.	1-6-1	34.04	**11**	1-12-1	35.38
6.	1-7-1	19.38			

5.3 *Identify savings Matrix*

We'll determine the sum of the saving matrix from the distance matrix. Every single delivery of the goods is consumed by visiting some. We will obtain the value of the savings by the formula which is following:

$$S(x, y) = D(0, x) + D(0, y) - D(x, y) \quad \ldots. (2)$$

The saving values are given in Table 5 (Saving Matrix).

5.4 *Rank Savings*

Ranking the savings is the next step. The concept is to combine the two customers into the exact- vehicle, the combination of which provides the highest savings.

- We have ranked the savings in order from high to low. The highest savings of 38.65 are obtained from the savings matrix shown in the next table (Table-6) by combining Customers GT and WTP with the exact vehicle.
- The next highest value of 36.03 will be achieved by merging Mansarover and GT customers with the exact vehicle and so on.

Table 5
Saving Matrix

	Chomu Puliya 1	Jhotwara 2	Heerapura 3	Mansarover 4	Murlipura 5	Choura Rasta 6	Malviya Nagar 7	Raj Mandir 8	Gourav Tower 9	WTP 10	Gurjar ki thadi 11
ChomuPuliy1	0	9.89	9.99	6.00	4.00	0.08	3.23	9.20	6.14	5.98	0.02
Jhotwara2		0	24.40	12.50	7.38	0.09	6.47	19.26	14.06	13.59	0.06
Heerapura3			0	18.52	10.24	5.96	9.59	23.51	20.16	19.15	0.12
Mansarover4				0	0.33	3.13	25.48	7.67	36.03	36.02	7.64
Murlipura5					0	9.75	0.35	13.41	0.39	0.31	9.64
Choura Rasta6						0	7.30	1.32	3.16	3.29	18.59
Malviya Nagar7							0	2.86	26.52	11.80	14.76
Raj Mandir8								0	8.16	7.75	0.61
GouravTower9									0	38.65	7.92
WT10										0	8.09
Gurjar kithadi11											0

Figure 1 (The Route from dealshare source point (Jagatpure) to Murlipura) shows one route of possible routes between Source point and Murlipura. Figure 2 (The Route from Murlipura to dealshare source point (Jagatpure)) shows one route of possible routes from Murlipura to Source Point.

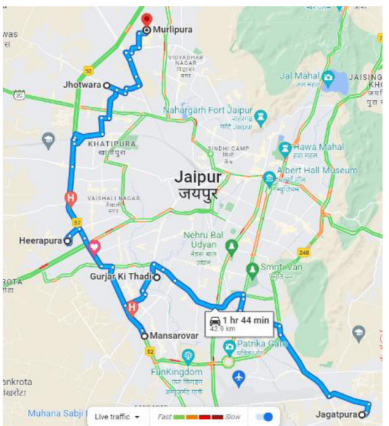


Figure 1

The Route from dealshare source point (Jagatpure) to Murlipura

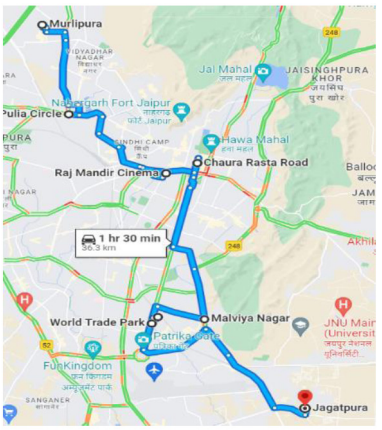
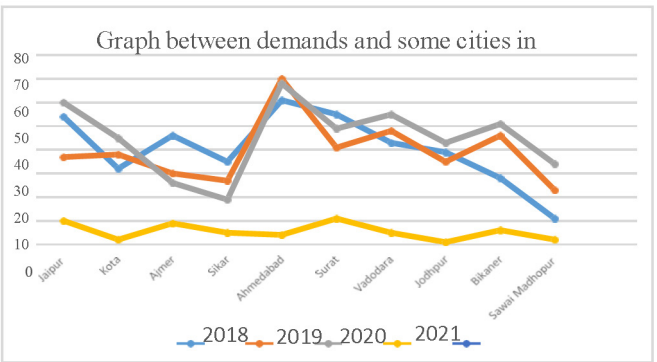


Figure 2

The Route from Murlipura to dealshare source point (Jagatpure)



Graph 1

Comparison of demands in various places

Graph 1 (Comparison of demands in various places) represents a comparison of demands at some places in different years. The allocation of each client could be merged into one route, up to the limit of the transport capability of the firm [14-15]. The combiner starts with the most

outstanding value for savings. We will start from the 38.65 savings cost, which is the savings from the merger of the Heerapura client and GT client. The value of each client's burden is 480 Kg and 670 Kg, while the total load is 1150 Kg. The total is still lower than the optimum transport capacity limit of 1500 kg. Consumer 4 (Heerapura) and consumer 10 (GT) join Route 1 (Jagatpura), and so on, so the merger is feasible [17-18]. Next is to sort customers along a defined path. The possible best path determination is performed using the Nearest Insert process. It is done by selecting clients with different minimum distances if inserted into an existing route. At first, it had only a zero-distance journey from the warehouse to the warehouse; then, adding each consumer to the current route showed how much distance took place. The results are as follows:

$$1\text{-}4\text{-}1 \longrightarrow 50.46$$

$$1\text{-}10\text{-}1 \longrightarrow 40.48$$

The optimum value is 40.48 km, the consumers visited are 10. Path 1-10-4-1 is the route formed, and so on.

6.1 *Proposed Product Distribution Routes*

There are 5 routes, limited by the total routes of Dealshare Private, from the optimal results of the processing and analysis. Over the next year, to distribute its products. The path is grouped by SMM. We have obtain 5 the optimal solutions of the given optimization problem in Table 6 (Optimal Routes of the Problem with Optimal Results).

Table 6

Optimal Routes of the Problem with Optimal Results

S.No.	Route	Delivery Schedule	Total distance	Total order Load (Kg.)	Conveyance
1.	ROUTE 1	1-10-4-1	70.78	1150	Pick-up
2.	ROUTE 2	1-11-5-1	38.84	1315	Cargo Truck
3.	ROUTE 3	1-12-8-1	55.54	1070	TATA-407
4.	ROUTE 4	1-6-9-1	47.45	720	Ven
5.	ROUTE 5	1-3-7-1	43.99	1310	Tempo

7. Conclusion

Our findings indicate that our approach performs better when the stochastic of using the NN criteria is near 1. In addition, we plan to include other measures for better results. Some different trajectories for research would be to use our method to quickly obtain satisfactory possible best results and then implement local search methodologies.

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