Solving Time Window Constraint Routing and Scheduling Problem

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Abstract : As high-rise buildings and population are growing simultaneously. Reaching destinations in a building itself on time can often become a major issue. But these problems can be solved efficiently with the help of transportation problem. In this research paper we have spoken about how the students of NMIMS (Narsee Monjee Institute of Management studies) usually face the problem of missing their first lecture because of waiting for a lot of time for the lifts for reaching from the gates to the 7th floor. Therefore, to solve this problem we made use of the transportation problem using an interactive system for optimum solution. Our idea is that whenever a student enters the gates via their ID cards, they should be directed to the lifts which are less crowded and which would help them reach the 7th floor in the least possible time frame. This would basically distribute the students in such a way that there is no overcrowding in the respective lift areas. We have collected the primary data from the NMIMS building itself and this problem is solved through Vogel's Approximation method and Modified distribution method on the software Tora (ed 8) .

***Index Terms* – Time window constraint, Routing and Scheduling Problem**

I.INTRODUCTION

Transportation is a significant fragment of the everyday life of every urban citizen. Efficient transportation routes not only save time and money but also help in stimulating the economy of any state. The ailment of conveyance services and facilities improves or weakens the living and working conditions, augments or troubles the environment of the area and heavily impacts the general prestige of the community. Transportation problem is one of the major areas of application of linear programing. It is the method to compute the minimum time and cost when an object travels from point A to point B.

Our motivation:

We mainly got motivated to construct this framework when we saw the kind of routing facilities at the airports. When we travel via air, we go to the respective airports for our departure. At the airport, there are several Operational research techniques which are used for smooth and efficient procedure of work. One of the examples are, during the security check-in (frisking), to avoid congestion, passengers are allotted specific check-up lines through which they have to proceed. This prevents too many people going to the same line which causes overcrowding.

Hence we thought that a similar framework can be added in our college too, here the main problem was overcrowding near the lift areas due to which students used to get late for their lectures. Henceforth we applied the transportation problem to this issue, we collected the raw data by taking the average amount of time that it takes from all the gates till the seventh floor lifts and computed the total number of students entering the gates between 7.15 to 7.45 (demand) and the number of lifts (supply) . This way we prepared an entire framework of the transportation problem and got the minimum amount of time that could take to reach the lifts.

This would basically distribute the students in such a way that there is no overcrowding in the respective lift areas.
The transportation problem can be solved by using the following three methods:

1. North west corner method
2. Least cost method
3. Vogel's approximation methods

Out of these methods we have used Vogel's Approximation method in order to derive the most optimum feasible solution.

II.LITERATURE REVIEW

A platform for computing a Transportation Problem using an interactive system for optimal feasible solution.

The study of this research paper has been taken place at Ambrose Alli University in Ekpoma . The research paper is conducted by C.U Onianwa and F.I Sadiq (C.U onianwa, 2012) . The objective of conducting the research paper was to reduce the transportation cost for the students and staff, to and from the campus in a bid to reducing the internal cost and considering the convenience of the passengers. To solve this issue they used the Microsoft visual basic 6.0. software design using the AAU transportation problem. Hence through this software the optimum feasible solution was 11050 and initial basic solution was 11200. This mainly helped to identify the transportation routes and then structure the system to obtain a model that will help the management to function at a reduced cost.

A Study of transportation problem for an essential item of southern part of north eastern region of India. This research paper is written by (Nabendu Sen, 2010). The objective of this paper was to construct a better supply chain of rice from Silchar to different markets of Mizoram. To solve this problem a transportation model was developed which was solved through the Vogel Approximation method and the solution obtained was 22,10,000 and to find the optimum solution the modified distribution method was used in which the solution was 12,46,000. This method helped in finding out the routes which could not only help to reduce cost but also shelter a good market coverage area.

The minimum spanning tree problem is a related line of research which has dealt with the minimum spanning tree problem with time window constraints (MSTPTW). The importance of this research rests with the fact that it indicates that time window constraints alter the computational complexity of even "easy" problems involving routing components. While the minimum spanning tree problem can be solved optimally in $O(n^2)$ time (e.g., P RIM), in SOLOMON[1] it is shown that the problem with time windows is NP-hard by a polynomial transformation from the bounded diameter spanning tree problem.

The Travelling Salesman Problem is a VRPTW involving only one un capacitated vehicle. Research on the TSPTW has focused on exact algorithms to minimize the total distance traveled. CHRISTOFIDES et al[2] discuss state space relaxations for dynamic programming approaches to this problem. The lower bounds obtained from the relaxed recursions could be maximized by the use of sub-gradient optimization and "state space ascent" and used in branch-and-bound algorithms for these problems. The authors provide a short summary of computational results. Problems with up to 50 customers are considered. For the largest problems, an average (over 5 problems) of 21 seconds, and a maximum of 42.2 seconds of CDC 6600 CPU time were used.

Transportation Linear Programming Algorithms to Cost Reduction – by A.O.Salami (A.O.Salami, 2014)

This product was based on application of Transportation Linear programming algorithms to reduction of cost in Nigerian soft drink industry. The objective of this study was to determine ways of minimizing transportation cost in order to maximum profit. This problem was solved by using the all the three methods which are NWC method, least/minimum cost method and Vogel's approximation method. After solving the transportation problem by all the three methods, the total cost of the solution came down to N1, 358, 019.00. finally, A.O.Salami found a way to reduce the cost of distribution of 7 up bottling agency which gradually leads to higher profits for that company.

III.METHODOLOGY

- **Collection Of data**

The data is collected by the authors of the research paper themselves. The time from one demand center to one supply center is calculated by averaging the actual 10 timings of every possible route which were noted by the authors. The timings were taken on each day of 2 consecutive weeks [working days (from Monday to Friday)]. The time measurement- the time taken by a person to walk from the RFID Scanner gate to reach the 7th floor.

Total Supply is estimated by the totaling the number of students entering the building between 7:15-7:45(GMT+5:30). And the supply is divided among the demand centers in the proportion it calculated by the capacity each demand center can take.

- **Assumptions**

1 All the lifts are in working condition and goes up to the 10th floor.

2 For this problem, it is assumed that the student wants to reach to the 7th floor from the ground floor and the only mode of transportation is the lifts.

3 The average speed at which the person walks is 7km/h.

- **Solving**

To reach the IBFS Modified Distribution method is used and to get the optimum solution Vogel's Approximation method is used.

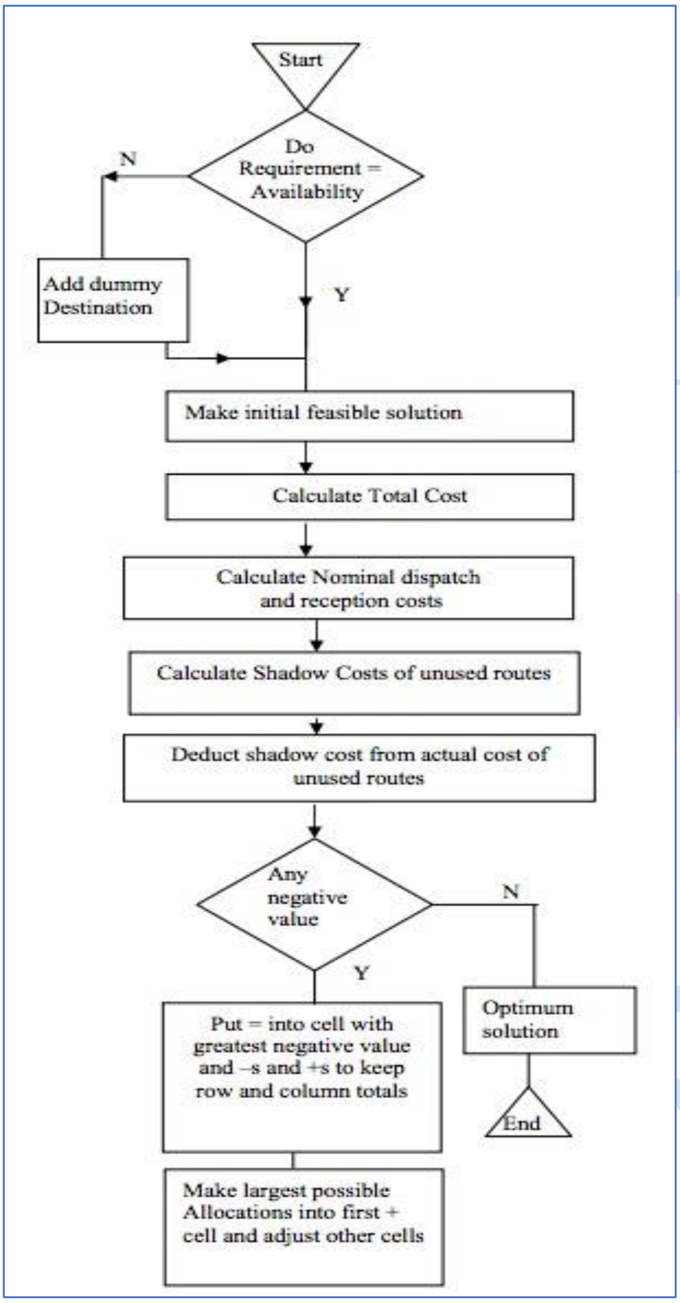
To solve the problem Excel Solver is used.

Mathematically a transportation problem is nothing but a special linear programming problem in which the ob$_j$ective function is to minimize the cost of transportation sub$_j$ected to the demand and supply constraints.

The transportation problem applies to situations where a single commodity is to be transported from various sources of supply **(origins)** to various demands **(destinations).** Let there be *m* sources of supply s_1, s_2, …...............s_m having ai (i = 1,2,......m) units of supplies respectively to be transported among *n* destinations d_1, d_2………d_n with b_j (j = 1,2…..n) units of requirements respectively.

Let c_{ij} be the cost for shipping one unit of the commodity from source i, to destination j for each route. If xij represents the units shipped per route from source i, to destination j, then the problem is to determine the transportation schedule which minimizes the total transportation cost of satisfying supply and demand conditions.

The transportation problem can be stated mathematically as a linear programming problem as below:



$$\text{Minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

Subject to constraints,

$$\sum_{j=1}^{n} x_{ij} = a_i \qquad i = 1,2,\ldots..m \text{ (supply constraints)}$$

$$\sum_{i=1}^{n} x_{ij} = b_j \qquad j = 1,2,\ldots..m \text{ (demand constraints)}$$

and $x_{ij} \geq 0$ for all $i = 1,2,\ldots..m$ and,

$j = 1,2,\ldots..m$

Mathematical Model. Retrieved from

https://www.wisdomjobs.com/e-university/quantitative-techniques-for-management-tutorial-297/mathematical-formulation-9881.html

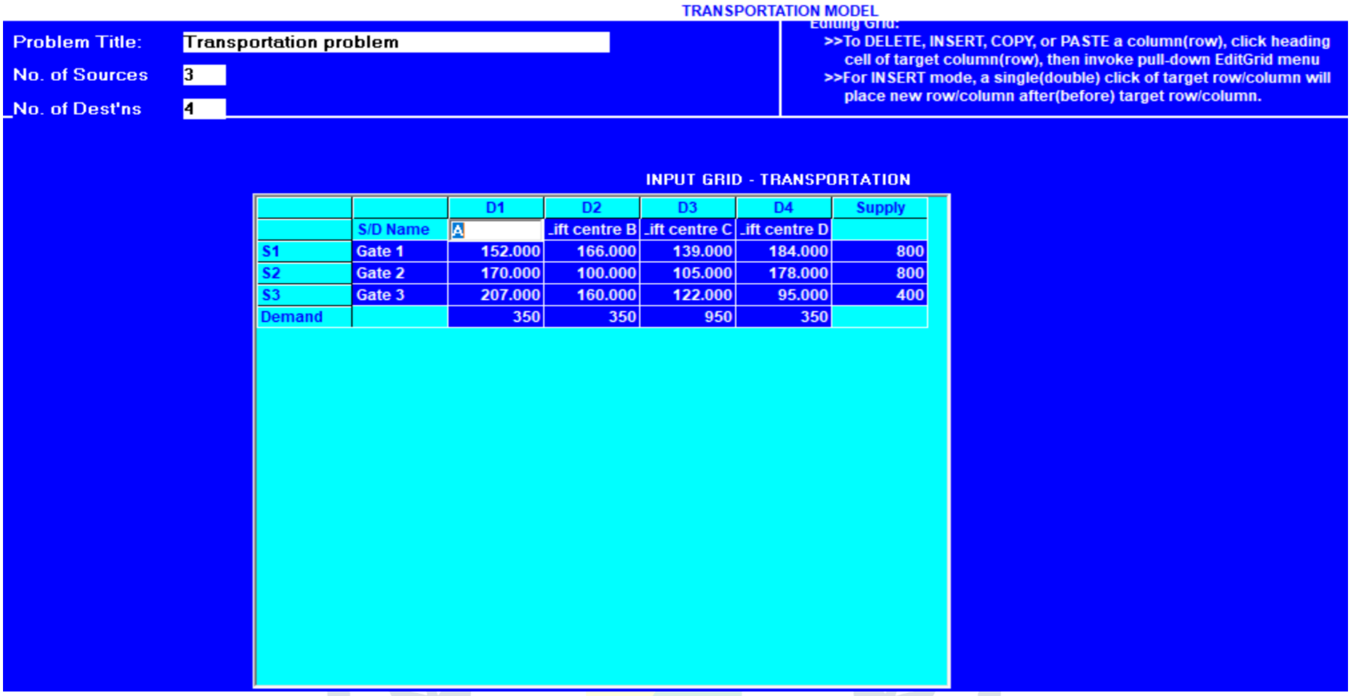
IV.DATA ANALYSIS

Here in this transportation table the supply i.e (S1,S2,S3) are the entrance gates , and the demand i.e (D1,D2,D3,D4) is the lift capacity.

In total there are 12 lifts and 2000 children, where Lift center A has 2 lifts, Lift center B has 2 lifts , Lift center C has 6 lifts , Lift center D has 2 lifts. We have proportionately divided the supply (i.e the no of children to the no of lifts) and rounded it off (2000/ 12 = 166.67) .

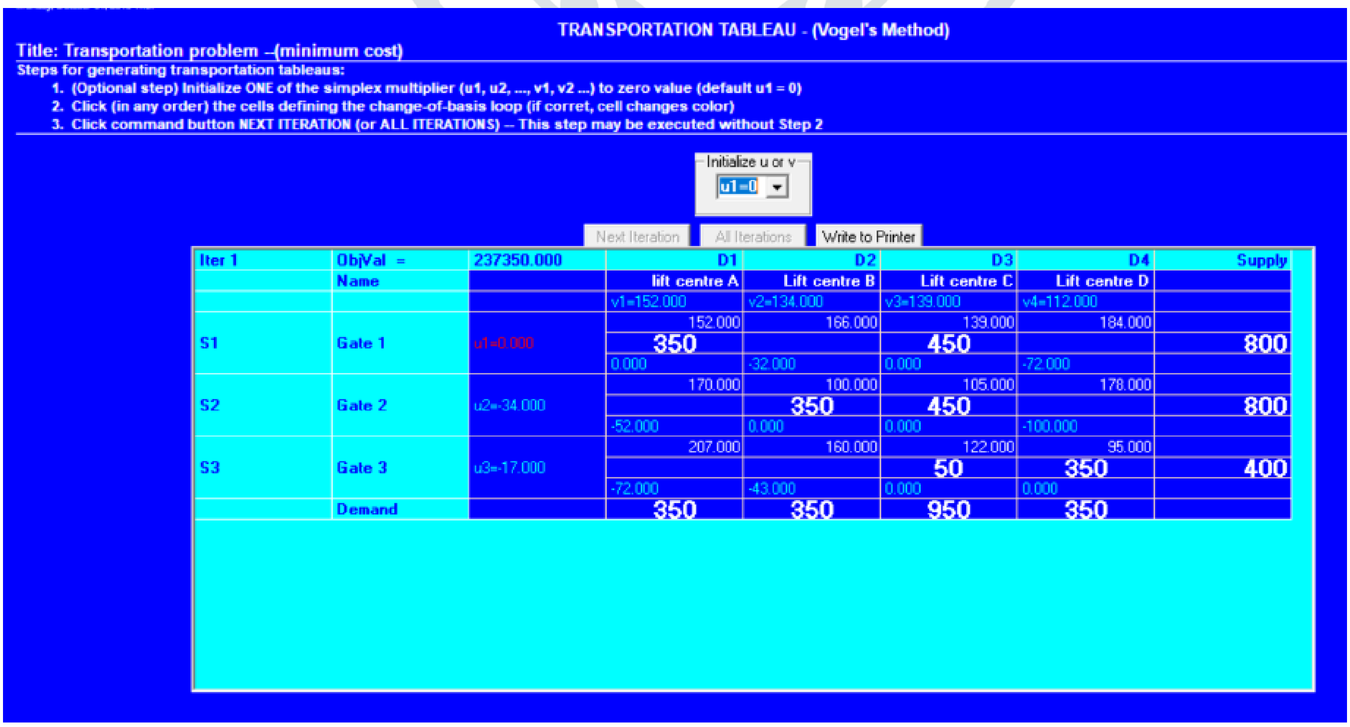
Here in this case instead of the cost we have taken time in seconds. We calculated the average time taken by the students for reaching from the gates to the 7th floor lifts.

STEP 1



		D1	D2	D3	D4	Supply
	S/D Name	A	_ift centre B	_ift centre C	_ift centre D	
S1	Gate 1	152.000	166.000	139.000	184.000	800
S2	Gate 2	170.000	100.000	105.000	178.000	800
S3	Gate 3	207.000	160.000	122.000	95.000	400
Demand		350	350	950	350	

STEP 2

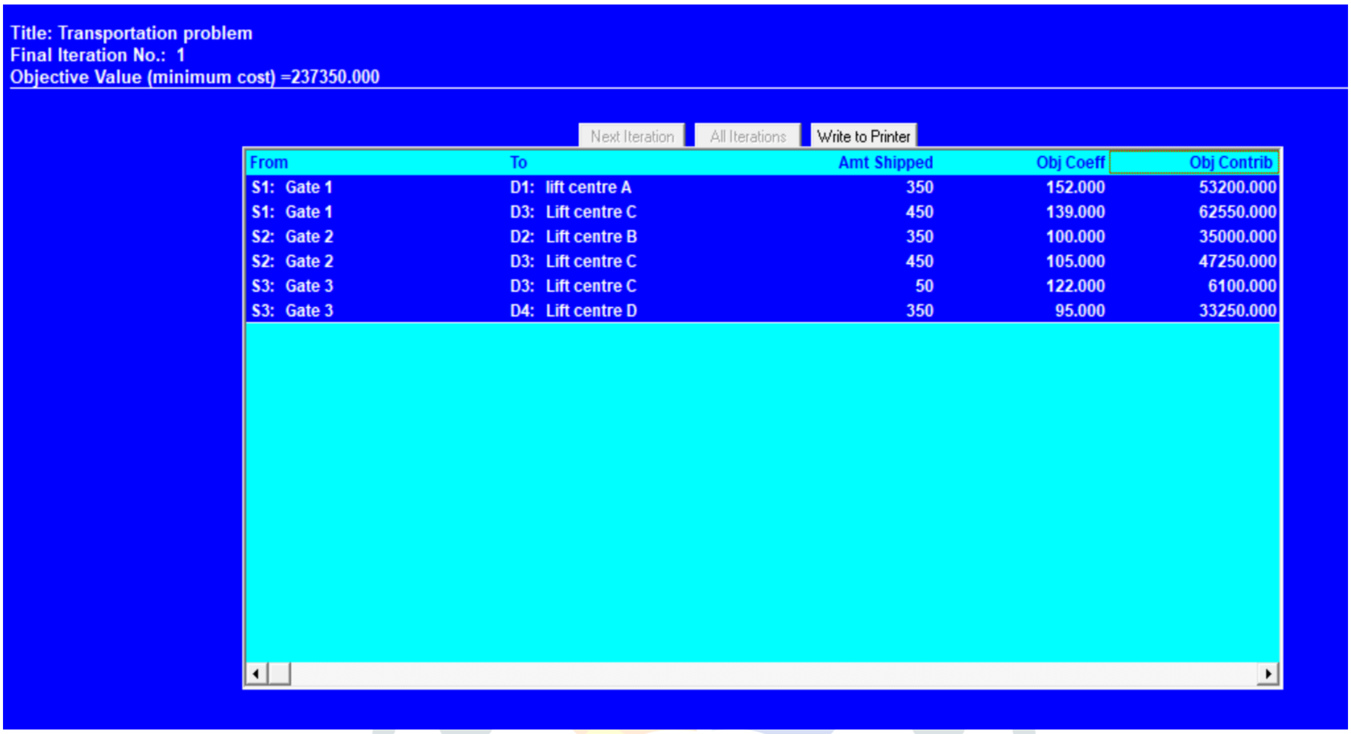


Iter 1	ObjVal =	237350.000	D1	D2	D3	D4	Supply
	Name		lift centre A	Lift centre B	Lift centre C	Lift centre D	
			v1=152.000	v2=134.000	v3=139.000	v4=112.000	
S1	Gate 1	u1=0.000	152.000 350 0.000	166.000 -32.000	139.000 450 0.000	184.000 -72.000	800
S2	Gate 2	u2=-34.000	170.000 -52.000	100.000 350 0.000	105.000 450 0.000	178.000 -100.000	800
S3	Gate 3	u3=-17.000	207.000 -72.000	160.000 -43.000	122.000 50 0.000	95.000 350 0.000	400
	Demand		350	350	950	350	

We do not have Basis Inverse, so we have to rely on the dual problem and the fact that the reduced time of the basic variables are zero we use the shadow prices, hence we need to look at the dual of the transportation problem.

Here Δij is the opportunity time or change in the time for an empty cell , Δij = Time – (Ui +Vj) . Suppose the Δij value is positive i.e 50 , it means that a student will take 50 seconds extra through that path and the total minimum time will increase by 50 seconds .

STEP 3



Title: Transportation problem
Final Iteration No.: 1
Objective Value (minimum cost) =237350.000

Next Iteration | All Iterations | Write to Printer

From	To	Amt Shipped	Obj Coeff	Obj Contrib
S1: Gate 1	D1: lift centre A	350	152.000	53200.000
S1: Gate 1	D3: Lift centre C	450	139.000	62550.000
S2: Gate 2	D2: Lift centre B	350	100.000	35000.000
S2: Gate 2	D3: Lift centre C	450	105.000	47250.000
S3: Gate 3	D3: Lift centre C	50	122.000	6100.000
S3: Gate 3	D4: Lift centre D	350	95.000	33250.000

The total minimum time (seconds) = 237350

V.CONCLUSION

So, the objective of the research was to minimize time for a student to reach the destination and to avoid congestion at a particular lift center. The problem was solved using Tora software and Vogel's Approximation Method was used to find the IBFS and Modified Distribution to derive the optimum solution. The Minimum time we got is 237350 seconds, which means that tthe total number of minutes is (237350/60) 3955.833 and therefore, the average time taken by a student to reach their destination using this method is (3955.833/2000) 1.977 minutes. This problem can be solved if a monitor is installed on the IRFD gates. As soon as the student scans their ID cards, the monitor instructs the student toward which lift center the student should go so as to avoid the congestion and which will take minimum time for them to reach their destination. Probably this solution is more cost effective then installing extra lifts in the building and this kind of approach can be used in various buildings because the lift issues are very common.

VI.REFERENCES

A.O.Salami. (2014). Application of Transportation linear programming Algorithms to cost reduction in nigeria soft drinks industry. *International science index , economics and management engineering*, 7.

C.U onianwa, F. (2012). A platform for solving transportation problem using an interactive system for optimal solution *african journal computing and Ict*, 6.

Nabendu Sen, T. S. (2010). A study of transportation problem for an essential item of southern part of north eastern region of india as an or model and use of object oriented programming . *IJCSNS international journal of computer science and network security* , 9.

1. Prim RC. Shortest Connection Networks And Some Generalizations. *Bell Syst Tech J*. 1957. doi:10.1002/j.1538-7305.1957.tb01515.x

2. Christofides N, Mingozzi A, Toth P. State-space relaxation procedures for the computation of bounds to routing problems. *Networks*. 1981. doi:10.1002/net.32301102