Computer-Based Distribution Optimization System Using Transportation Model

Esiefarienrhe B.M., Deke B. Tertsea, Ogunbunmi C. T.

Abstract— ***Computer Based Distribution Optimization System is computer software based system designed to generate optimal distribution routes for companies with two or more production plants and two or more distribution centers, using the transportation model. The model aims at minimizing the cost of transporting commodities from production plants to various distribution centers. The Least Cost Method (LCM), Vogel's Approximation Method (VAM) and the Modified Distribution Method (MODI) were used to generate routes. The system compares the initial basic feasible solution (IBFS) of the three methods and uses the routes generated by the method with the smallest IBFS as the most optimal distribution route that minimizes total transportation cost. The Object-Oriented Analysis and Design (OOAD) methodology was used in the analysis and design of the system. Java programming language (J2EE) was used to develop the system and My Structured Query Language (MySQL) to design and manage the database. The results generated by the system shows the optimal routes to be followed when distributing products that will lead to the minimum cost of distribution to the organization.***

Keyword:- Distribution Optimization, Least Cost method, Vogel's algorithm, Modified Distribution method,

I. INTRODUCTION

Transporting goods from one warehouse to another or from one sales point to another has often been responsible for the substantial cost of most organization producing goods or rendering services. This cost can be reduced if appropriate studies are conducted to find the least cost and most efficient route. Although the least cost route may not be the ideal route, namely because of potential risk inherent, it is possible to also combined various criteria in route selection.

One of the most important and successful applications of quantitative analysis to solving business problems has been in the physical distribution of products, commonly referred to as transportation problem (TP). Basically, the purpose is to minimize the cost of shipping goods from one location to another so that the needs of each arrival area are met and every shipping location operates within its capacity (Reeb and Leavengood, 2002). The study of TP helps to identify optimal transportation routes along with units of commodity to be shipped in order to minimize total transportation cost (Sharma, 2009).

Manuscript received June 25, 2018

Esiefarienrhe B.M., Maths/Stats/Computer Science Department University of Agriculture, Makurdi, Benue State, Nigeria.

B.M., Deke B. Tertsea, Maths/Stats/Computer Science Department University of Agriculture, Makurdi, Benue State, Nigeria.

Ogunbunmi C. T., Maths/Stats/Computer Science Department University of Agriculture, Makurdi, Benue State, Nigeria.

Whenever there are physical movement of goods from the point of manufacturer to the final consumers through a variety of channels of distribution (wholesalers, retailers, distributors etc.), there is a need to minimize the cost of transportation so as to increase profitability. basing distribution on human calculations and judgment has often lead to shortage of products and some sales point or warehouse and excess at some other warehouse or sales points. This is because human judgment based on say experience, expertise or training are not scientific and therefore are bound to fail. Although scientific methods sometimes do fail, but the probability of such failure is extremely low.A lot of situation do arise which would make the marketing managers or sales managers in an organization to determine the total number of goods that goes to a particular depot/sales point at a particular period (Gupta and Hira, 1998).

In this research, we shall apply the linear programming method for a real world application of a transportation model that involves the distribution of homogeneous product of a company from several supply centers to several demand centers so as to guide the company in minimizing the cost of moving her products to demand areas. Computer programs are then written using the models so as to enable the computer to solve the analytical task in other to generate an optimized solution that minimizes the transportation cost.

II. LITERATURE REVIEW

According to Aramuthakannan and Kandasamy (2013), their work on new approach to transportation problem namely, Revised Distribution method (RDI) was used to solve a wide range of such problems. The new method is based on allocating units to the cells in the transportation matrix starting with minimum demand or supply to the cell with minimum cost in the transportation matrix and then try to find an optimum solution to the given transportation problem. Their proposed method used a systematic procedure, easy to apply and can be utilized for all types of Transportation problem with maximize or minimize objective functions.

Soomro et al., (2015) presented a Modified Vogel's Approximation Method (MVAM) to find an initial basic feasible solution for the transportation problem. The three methods, North West Corner Method (NWCM), least Cost Method (LCM) and Vogel's Approximation Method (VAM) was used to find initial basic feasible solution for the transportation model. The authors took same transportation models and used MVAM to find its initial basic feasible solution and compared its result with above three methods, but MVAM gave minimum transportation cost and also optimal and in some problems the result of MVAM was same as VAM but better than NWCM and LCM.

Salami (2014) examined ways of minimizing transportation cost in order to maximize profit using data from the records of the Distribution Department of 7-Up Bottling Company

Plc. Ilorin, Kwara State, Nigeria. The data were computed and analyzed using the three methods of solving transportation problem. The result showed that the three methods produced the same total transportation costs amounting to N1, 358, 019, implying that any of the method can be adopted by the company in transporting its final products to the wholesale dealers in order to minimize total production cost.

Stojanović et al., (2014) described a general model of the transportation problem, as well as some methods for determining the so-called initial basic solutions and optimization of transportation programs. The main part of their research contains algorithms and software for implementation of the described transportation problem solved methods within the original software package, in the form of MS Access database, and written in VBA (Visual Basic for Application) programming language. They represented a complete and comprehensive software tool which completely solves the transportation problem.

Afroz and Hasan (2015) developed an algorithm and its computer oriented program for solving transportation programming (TP) reducing it into a linear program (LP). After formulating it into linear programming problems the number of variables becomes large. It then, becomes more difficult and time-consuming if it is done manually with simplex method. By using the computer program the solution can be found in a shorter time. The authors were able to show that a TP with a large number of variables could be solved in few seconds by using the program. A number of numerical examples were presented to demonstrate the method developed in their research.

Malathi (2015) designed four methods (Northwest Corner method, Vogel's approximation method, Column Minimum Method, Least cost method) of transportation model in Linear Programming using the four algorithms. After designing for the four methods he developed C program for each one. He then used C language to facilitate getting the result and complex problems which takes long time using Linear Programming solution. After running the programs, Malathi compared between each solution using C program and Linear Programming solution which showed that they have the same result. The main idea of designing four C programs is to save time, money, and effort.

Akpan et al., (2015) also proposed a Modified Vogel's Approximation Method for solving balanced transportation problems for Initial Basic Feasible Solutions (IBFS) and the result was compared with existing methods. The proposed method was shown to be better than existing ones (excluding Vogel's Approximation Method) since it does not only considers each unit cost in its solution algorithm, but also minimizes total cost (comparatively) just like Vogel's Approximation Method.

Thiruppathi and Iranian (2015) proposed an innovative method called TVAM used to find an optimal solution for any assignment problem in single stage. Here the assignment problem is solved to get optimal solution directly. A numerical illustration is established and the optimality of the result yielded by this method is also checked. This method is more lucrative for decision makers and efficient while comparing with other existing methods because of its simplicity and less calculation time.

Sood and Jain (2015) proposed a new method for finding an initial basic feasible solution of a transportation problem. The method was named Maximum Difference Method. This method gives an initial basic feasible solution of the transportation problem, which is most of the time better than that of Vogel's Approximation Method (VAM). The proposed algorithm was illustrated using some numerical examples.

Hlayel and Alia (2012) used the best candidate method (BCM); in which the key idea is to minimize the combinations of the solution by choosing the best candidates to reach the optimal solution. Comparatively, applying the BCM in the proposed method obtained the best initial feasible solution to a transportation problem and performs faster than the existing methods with a minimal computation time and less complexity. The proposed method is therefore an attractive alternative to traditional problem solution methods.

Anuradha et al., (2012) presented a new method named interval-point method without using fuzzy set theory for finding an optimal solution for unbalanced transportation problems with budgetary constraints where demand and budget are imprecise. With the help of numerical example, the proposed method was illustrated. The proposed method enables the decision makers to choose the optimal distribution according to their budget.

Rekha et al., (2014) applied the transportation model to determine the reduction in Transportation cost (TC) of tools which appeared to be an important component of the total cost of production. The algorithm determines the Initial Basic Feasible (IBFS) Solution of Transportation Problem (TP) to minimize the cost. The result with an elaborate illustration demonstrated that the method presented was effective in minimizing the transportation cost.

Girmay and Sharma (2013) analyzed Vogel's Approximation Method and its modification due to Shimshak (1981) and Goyal (1984) in finding an initial solution to an unbalanced transportation problem. They suggested a heuristic approach in order to balance the unbalanced transportation problem and improve the Vogel's Approximation Method (VAM) in order to get improved (sometimes) initial solution of unbalanced transportation problem in comparison to usual VAM. The algorithm was supported by numerical illustrations.

Vogel's Approximation Method (VAM) is the more efficient algorithm to solve the transportation problem but it has some limitations when highest penalty cost appear in two or more row or column. For that case VAM does not give any logical solution. Das et al., (2014) proposed a logical approach for this problem and developed an algorithm named by "Logical Development of Vogel's Approximation Method (LD-VAM)" where feasible solution from this method are very close to optimal solution more than VAM.

Palaniyappa and Vinoba (2014) coded and tested the south east corner (SEM) procedure successfully via many randomly generated problem instances. Based on the results they concluded that the correctness of the newly coded SEM was promising as compared with the previously coded one. In their research, the corrected coding of SEM was implemented using C++. Then the correctness was verified via many randomly generated instances.

Palaniyappa and Vinoba (2014) continued their research by presenting the North east corner (NEM) procedure which was successfully coded and tested via many randomly generated problem instances as well. From the results they got; it can be concluded that the correctness of the coded NEM is also promising as compared with the previous one. This time they

selected very big problem of Transportation problem using Object oriented programming in C++ and developed a NEM in C++ Flowchart, Algorithm and a program.

III. METHODOLOGY

The procedures, methods and techniques used for the analysis and design of the proposed *Computer-based Distribution Optimization System Using the Transportation Model;* was done using the Object-Oriented Analysis and Design (OOAD) methodology.

Analysis of the Existing System

The Marketing Managers of each production plant and each distribution center are responsible for taking and keeping records of the quantity of products produced and the quantity of products needed respectively. All these records and other calculated results and decisions done by these managers are processed and stored on papers. Also, from the existing system observed, each production plant is assigned specific areas or distribution centers to which they can supply their products to. Every distribution center has its own demand quantity separate from others; this will force the production plant to produce products exactly equal to or greater than the total demand from the various distribution centers assigned to the plant. Now, in the case where the production plant cannot produce the total demand, some or all the distribution centers assigned to the plant may not receive the quantity of products they require. Meanwhile, there may be other plants with total production greater than the total demand and because they are not required to supply outside their jurisdiction the excess products will be shared among the distribution centers under that plant. Hence, there is no procedure for allotting products evenly among each distribution center based on their demand. It can also be noted that the transportation cost from a production plant to the various distribution centers assign to the plant is different for each distribution center. The Marketing Managers intuitively assume routes to be follow for the distribution of products without following any scientific approach; and hence, not knowing specifically if transport cost is minimized or not.

Analysis of the Proposed System

The system is built such that the general marketing manager of the company can create a single admin account that can perform virtually all the functionalities in the system. The admin can then add production plants and distribution centers that the company have. Transportation costs from all the production plants to all the distribution centers are also added. The admin then clicks generate routing information button to generate the routes each plant will follow to supply and the quantity of products to supply to the corresponding distribution center. This information can then be printed and sent to the transportation department.

Context Diagram

The context diagram, showing the boundaries, scope and objectives of the distribution optimization system is shown in figure 1.

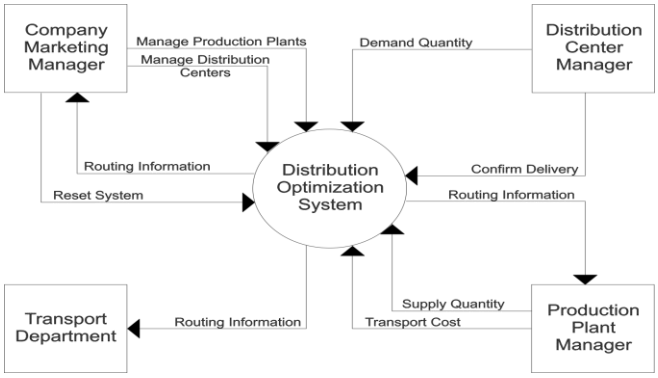

Figure 1: Context Diagram of the proposed Distribution Optimization System

Database Design

All data and information used in the system are managed using a the relational database called MYSQL (My Structural Query Language).

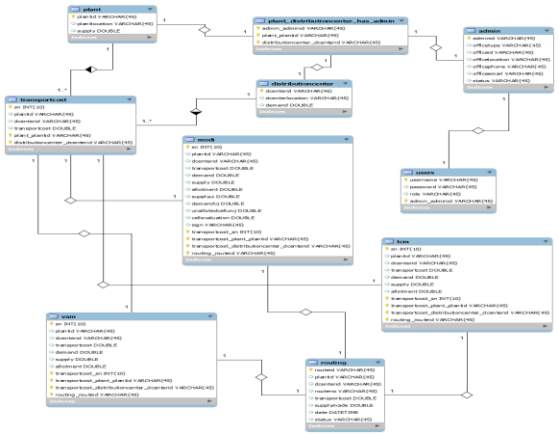

Figure 2: E-R Modeling Diagram from MYSQL Workbench

Use Case Diagram Below is the use case diagram showing the interaction between the distribution optimization system and its users.

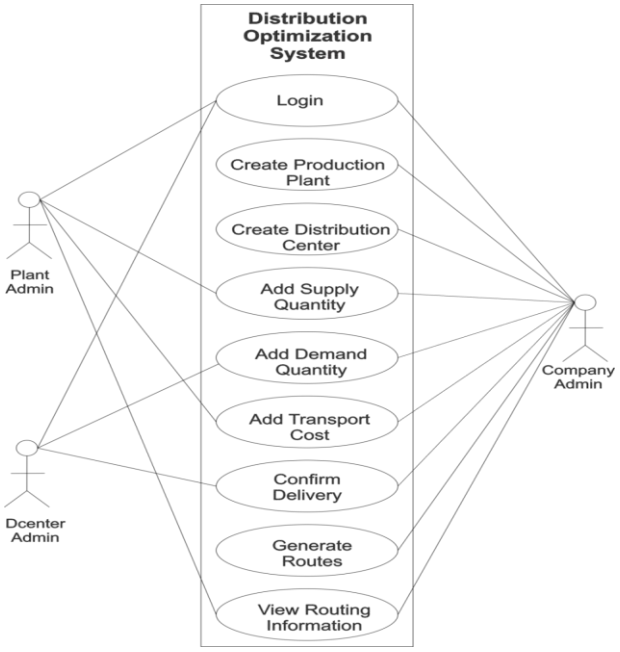

Figure 3: Use Case Diagram of the Proposed Distribution Optimization System

Algorithm

Three basic algorithms of the transportation model have been used to generate optimal solution for the distribution of products. These algorithms include:

i. Vogel's approximation

ii. Least cost

iii. Modified distribution

Vogel's Approximation Method (VAM)

This is an advance method and as such can be complicated. VAM has the advantage of arriving at optimal solution at first attempt (i.e. it both initiates and simultaneously solves optimally).

Steps: Formulate the transportation model table.

i. Determine the lowest cost in each column and subtract from the next lowest cost in that same column. The result is the opportunity cost of that column.

ii. Determine the lowest cost in each row and subtract from the next lowest cost in that row. The result is the opportunity cost in that row

iii. The row or column with the highest opportunity cost is selected. Allocation is then made to the cheapest cell in that row or column selected. If a tie (equality) occurs, select any one. Block necessary cells during allocations.

iv. Repeat steps i to iii, (ignoring blocked cells) and stop when the last allocation is made.

Least Cost Method (LCM)

Here, the method first guesses what the optimal solution might be with the initial table. It then uses this guess to distribute along the routes. Allocations are made on the basis of economic desirability i.e. we begin with the cell that has the lowest cost and to the next until all the distribution are exhausted. Efforts should be made to block cells which rows and columns have been satisfied.

Steps: Formulate the transportation model table.

i. Determine the least cost among all the rows of the transportation table.

ii. Identify the row and allocate the maximum feasible quantity in the cell corresponding to the least cost in the row. Then block the row (column) when an allocation is made.

iii. Repeat step i and ii for the reduced transportation table until all the available quantities are distributed to the required places. If the minimum cost is not unique, the tie can be broken arbitrarily.

Modified Distribution Method (MODI)

Steps Involved in Modified Distribution Method:

i. Obtain the initial table using any of the initial method (VAM or LCM)

ii. For each used route, break the cost into two components, i.e. Dispatch and Reception Costs Cij = Di + Rj.

iii. Solve the system of equation obtained in step ii above by assuming the first dispatch Cost to be Zero.

iv. Break each of the unused routes into Dispatch and Reception Costs

v. With the aid of the solution of the system of equation in step (iv), for each of the unused route, evaluate Cij – (Di + Rj) i.e. Actual Cost – Shadow Costs

vi. Check for the negative values in (iv) above, if there is none, the table is said to be optimal.

Choice of Programming Language

The system was developed using Java 2 Platform Enterprise Edition (J2EE) programming language (an object-oriented language) as the front end and MYSQL (Structured Query Language), a relational database management system used in designing the database as the back end. J2EE has an intuitive Integrated Development Environment (IDE) for Rapid Application Development (RAD). The front end is the graphical user friendly interface in which the systems users use to interact with the back end. It contains visual tools, menus used to view, navigate and manipulate records in the database. The back end contains the database where all records are stored. It contains database tables, queries and data manipulation tools.

RESULTS AND DISCUSSION

The system collects three basic inputs; the supply capabilities of all the production plants, the demand of all the distribution centers and the transportation cost from each plant to all the various distribution centers. Some of the routes collected by Salami (2014) from the Distribution Department of 7-Up Bottling Company Plc. Ilorin were used to test the system. The depots considered include; Osogbo, Ibadan, Ilorin, Mokwa, Ogbomoso with supply capabilities (in crates) of 1728, 2304, 2880, 1440, 2592 respectively.

The wholesale dealers considered include; Ede, Ejigbo, Oyo, Awe, Ilora, Offa, Erin-Ile with demand requirements (in crates) of 728, 500, 1000, 920, 760, 1200, 920 respectively. The cost per unit of transporting the products from their respective depots to required wholesale dealers are shown in Table 1:

Routes	Ede	Ejigbo	Oyo	Awe	Ilora	Offa	Erin-Ile
Osogbo	122	122	126	126	126	124	125
Ibadan	125	124.5	122.5	122.5	123	126	122.5
Ilorin	126	127	128	127	127	124	123.5
Mokwa	132	131	132	131	131	128	129
Ogbomoso	131	129	129	129	128	131	130

Table 1: Transportation cost from depots to wholesale dealers

Using the inputs in Table 1, the system generated optimal routes which the company should follow to minimize transportation cost. The result generated is shown in Figure 5:

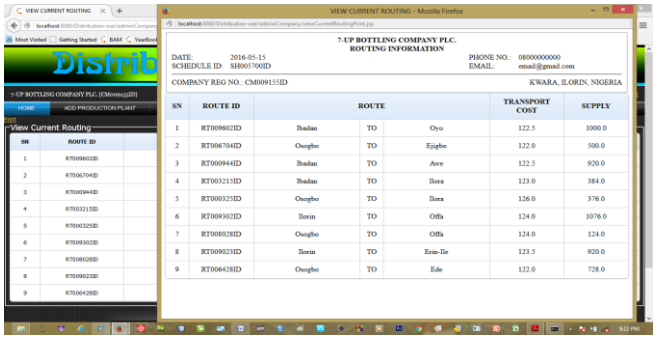

Figure 4: Company Routing Information (Ready for Printing)

Discussion of Results: based on the result shown in Figure 5; it is recommended that for total transportation cost to be minimized, the following routes should be used by the company:

- **Ibadan Depot:** should supply to Oyo, Awe and Ilora wholesale dealers.
- **Osogbo Depot:** should supply to Ejigbo, Ilora, Offa and Ede wholesale dealers.
- **Ilorin Depot:** should supply to Offa and Erin-Ile wholesale dealers.

CONCLUSION

The computer-based distribution optimization system is aimed to reduce the total cost of transporting goods from production plants to distribution centers thereby maximizing total profit. The software through its interactive interface can minimize the workload on marketing managers or those inchange of deciding distribution routes, save human labour and time. This is a very creative information technology system; the system can store the record of each distribution schedule and it can also recall when necessary reference is needed. Research carried out shows that the computerized system yields more advantages. The system can be modified to cover aspects deemed relevant by the company. Hence the system is of immense importance to the company with regards to the accomplishment of the company's distribution process.

REFERENCES

1. P.K. Gupta and D.S. Hira (1998), Problems in Operations Research: Principles and Solutions. S. Chend and Co. Ltd., New Delhi, 1998, chapter 3.
2. Sharma J.K., (2009) Operation Research (Theory and Application) 4th Edition. Macmillan Publisher, India.
3. Reeb J. and S. Leavengood, (2002) Operations Research (Transportation Problem: A Special case for Linear Programming Problems), Oregon State University, EM8779, $ 3.50.
4. O. Salami, (2014) application of Transportation Linear Programming Algorithms to Cost Reduction in Nigeria Soft Drinks Industry. International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering Vol.8, No.2, 2014
5. V. Stojanović, L. Spalević and M. Božinović (2014) Software Application for Solving the Transportation Problem: ERK'2014, Portorož, B: 23-26
6. Sharmin Afroz and M. Babul Hasan (2015) A Computer Oriented Method for Solving Transportation Problem: Dhaka Univ. J. Sci. 63(1): 1-7, 2015 (January)
7. R. Malathi (2015) Transportation Problem and Its Object Oriented Programming Languages: International Journal of Engineering Science Invention Research & Development; Vol. II Issue III September 2015.
8. S. Akpan, T. Ugbe, J. Usen and O. Ajah, (2015) A Modified Vogel Approximation Method for Solving Balanced Transportation Problems. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) (2015) Volume 14, No 3
9. Thiruppathi and D. Iranian (2015) An Innovative Method for Finding Optimal Solution to Assignment Problems. International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 8, August 2015
10. S. Sood and K. Jain (2015) the maximum difference method to find initial basic feasible solution for transportation problem. Asian Journal of Management Sciences, 03 (07), 2015: 08-11.
11. A. Hlayel and M. A. Alia (2012) Solving Transportation Problems Using the Best Candidates Method: Computer Science & Engineering, an International Journal (CSEIJ), Vol.2, No.5, October 2012
12. D. Anuradha, P. Pandian and G. Natarajan (2012) Solving Unbalanced Transportation Problems with Budgetary Constraints. Journal of Physical Sciences, Vol. 16, 2012, 85-92
13. S.Rekha, B.Srividhya and S.Vidya (2014) Transportation Cost Minimization: Max Min Penalty Approach. IOSR Journal of Mathematics (IOSR-JM) Volume 10, Issue 2 Ver. I (Mar-Apr. 2014)
14. N. Girmay and T. Sharma (2013) Balance an Unbalanced Transportation Problem by a Heuristic approach: International Journal of Mathematics and Its Applications Vol.1 No.1 (2013), pp.12-18(Galley Proof)
15. U. K. Das, A. Babu, A. R. Khan, A. Helal and S. Uddin (2014) Logical Development Of Vogel's Approximation Method (LD-VAM): An Approach To Find Basic Feasible Solution Of Transportation Problem: INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 3, ISSUE 2, FEBRUARY 2014
16. R. Palaniyappa and V. Vinoba (2014) A Study of South East Corner Method and Use of Object Oriented Programming Model: International Journal of Mathematics Trends and Technology – Volume 8 Number 1 – April 2014.
17. R. Palaniyappa and V. Vinoba (2014) A study on North east corner method inTransportation Problem and using of Object Oriented Programming model (C++): International Journal of Mathematics Trends and Technology – Volume 16 Number 1 Dec 2014.
18. S. Aramuthakannan and Dr. P.R. Kandasamy, Revised Distribution Method of finding Optimal Solution for Transportation Problems. IOSR Journal of Mathematics (IOSR-JM), 2013

S. Soomro, M. Junaid and G. A. Tularam, (2015) Modified Vogel's Approximation Method for Solving Transportation Problems. Mathematical Theory and Modeling, Vol.5, No.4, 2015