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A Study of Transportation Problem in a Company for Supply for Supply of Wheat

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Abstract: ***In this paper, we formulate an Operations Research model from the data collected from Shri Mahavir Agri tech which is a renowned supplier of wheat in Madhya Pradesh. We tried to analyze the optimal transportation cost along with basic feasible transportation costs using North-West Corner Rule, Least Cost Method and Vogel's Approximation Method for this we considered the cities where the demand of their wheat is high and for supply their wheat production. Transport is regarded as a crucial factor in improving agricultural productivity. It enhances the quality of life of the people, creates a market for agricultural produce, facilitates interaction among geographical and economic regions and opened up new areas to economic focus. The cost minimization of the Indian food grain supply chain is a very complex and challenging problem because of the involvement of the many entities and their constraints such as seasonal procurement, limited scientific storages, varying demand, mode of transportation and vehicle capacity constraints. We obtained per tonne cost (in ₹) of transporting wheat from each plant to each city, from this data we obtained the optimal transportation cost and basic feasible costs, which gave us the most profitable transportation channel for the company. Our literature paper discusses the contribution of Hitchkock and Koopman. In the solution, we have made use of a dummy column and also assigned penalties. To come to our optimal feasible solution we have done looping to make sure there is no negative ij value.***

Keywords: supplier, wheat, transportation, optimal, cost, minimization, constaints, channel, solution, looping.

I. INTRODUCTION

One of the biggest problems that are faced by industries is to optimize economic cost as well as minimization of such cost that are affecting the company's revenue. The transportation model or problem are mainly concerned with the best possible way the product can be transported or supplied to different plants or warehouses. the objective in the problem is to fully satisfy the destination requirements within the operating production capacity constraints at the minimum possible cost.

Transport is regarded as a crucial factor in improving agricultural productivity. It enhances the quality of life of the people, creates a market for agricultural produce, facilitates interaction among geographical and economic regions and opened up new areas to economic focus. This paper, therefore, looks critically at the crucial role transportation plays in determining cost which is incurred on transporting wheat to the different parts of India. The cost minimization of the Indian food grain supply chain is a very complex and challenging problem because of the involvement of the many entities and their constraints such as seasonal procurement, limited scientific storages, varying demand, mode of transportation and vehicle capacity constraints. Wheat DDGS also called as Wheat Distillers Grains, are derived when the alcohol is extracted from wheat grain. Wheat DDGS feed, being rich in protein, is considered as one of the primary nutritional sources for poultry, fish, and cattle.

Shri Mahavir Agritech, a part of Mahavir group incorporated in the year 1975 has emerged as a pioneer in the manufacturing of Whole Wheat Flour and Wheat processing and a leading supplier of commodities like Chick Peas, Semolina Flour, Durum Wheat, Milling Wheat, All Purpose Flour and More. The Mahavir group was originally set up by Mr. Govind Bhai Shah in 1975 and was then taken up in the year 1985 and expanded by its current Managing Partner, Mr. Nitin Shah. With an expertise of over 40 years, the company has grown leaps and bounds to develop a phenomenal reputation in the industry as we believe in going a step further in diligently satisfying the customer.

II. LITERATURE REVIEW

The Transportation Problem: Case Study Of Coca-Cola Bottling Company Ghana.

Author: Nana Brany Bernard Kudjo Date: April 2013.

Transportation is the most important LPP model laying the foundation on the theoretical and algorithm development of minimum cost in relation to relative frequency. It derives the name from transporting goods to facility location. Hitchcock and Koopman used decomposition approach, reduction theorem and total opportunity cost method to obtain an initial basic feasible solution for transportation. Cost of transportation can be reduced by exploiting the criteria properties, relaxing constraints and increasing the slack variables. Three stages involved in transportation are planting depot, depot distributor and distributor dealer.

Transportation Problem: A Special Case For Kalka Based Flour Mill.
Author: Mohita Devi Date: June 2018.
Transportation helps manufacturing and multi-plant companies make strategic decisions satisfying supply and demand requirements within operating production capacity constraints at minimum cost. It is a technique adaptable to the changing conditions and identifying where to build extra capacity. It provides better insight into business problems by evaluating the cost and profit of alternatives. Advertising, telecommunication and HR sector make use of transportation to analyze audience coverage and providing the right job to the best person.
Implied Cost Method: An Alternative Approach To Find The Feasible Solution Of Transportation Problem.
Author: Md. Ashraful Babu; Md Abu Helal; Md Sazzad Hasan; Md Utpal Kanti Das
Year: 2014
Implied cost method is an alternative method which gives a feasible solution lesser than VAM almost coinciding with the optimal solution. It includes the product of the unit transport cost and the maximum amount of commodity allocated to the lowest implied cost according to demand and supply. The main aim of the method is to transfer the maximum amount of commodity to the lowest cost roots so the total cost will be minimum.
Fuzzy Optimal Solution to Fuzzy Transportation Problem: A New Approach
Author: S. Mohanaselvi; K. Ganesan
Date: March 2012
Fuzzy transportation problem whose decision parameters are fuzzy numbers aims to minimize the total fuzzy transportation problem while satisfying the availability and requirement limits. Liu and Kao proposed a new method using Zadeh's extension principle. Two-stage Fuzzy Transportation problem with trapezoidal fuzzy numbers was obtained by Abdul Razak. Applying the existing fuzzy linear programming techniques to solve the fuzzy transportation problem is the aptest method but provide only crisp solutions. The proposed algorithm avoids degeneracy. Optimal solution Is derived by applying the fuzzy version of MODI method.
Path Method For Finding A More-For-Less Optimal Solution To Transportation Problems
Author: P.Pandian, D.Anuradha
Date:2013
In this research paper mixed constraints like scheduling, production inventory, production distribution, allocation problems, and investment analysis are discussed however they are used less as they are rigorous. More-for-less (MFL) paradox helps in deciding the capacity of plant size or which markets to sought as with the increase in the number of goods to be transported optimal cost reduces. Charnes and Klingman obtained a feasible solution by relaxing the constraints and introducing new slack variables, however, it was tedious as it involved solving more variables of complex equations.
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
Author: Nabendu Sen; Tanmoy Som; Banashri Sinhas
Date: April 2010
Transportation has been the means of transporting goods from the place of supply to the meet the demands of poorly connected places. The different methods of transportation are Northwest cost method, least cost method, VAM and MODI method. The results obtained from c++ programming have confirmed that Vogel's method (VAM) gives initial feasible solutions closer to the optimal solution.

III. METHODOLOGY

Mathematical Formulation of a Transportation Problem:-
Mathematically a transportation problem is nothing but a special linear programming problem in which the objective function is to minimize the cost of transportation subjected 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 s1, s2,…….....sm having ai (i = 1,2.....m) units of supplies respectively to be transported among n destinations d1, d2……dn with bj (j = 1,2…..n) units of requirements respectively.
Let cij be the cost for shipping one unit of the commodity from a source I, to destination j for each route. If xij represents the units shipped per route from the 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.

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

1) Transportation Table: A transportation problem can be represented In a tabular form.

TABLE 1.1

To / From	D_1	D_2	...	D_n	Supply A_i
S_1	C_{11} x_{11}	C_{12} x_{12}	...	C_{1n}	A_1
S_2	C_{21} x_{21}	C_{22} x_{22}	...	C_{2n}	A_2
. . .	. . .	. . .	... ...	. . .	. . .
S_m	C_{m1} x_{m1}	C_{m2} x_{m2}	...	C_{mn}	A_m
B_j	B_1	B_2	...	B_n	$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

In table 1.1 S1, S2 & SM represents the places from where the commodities are being supplied and D1, D2 & D3 represents the places where the commodities are being supplied to.
Cij is the cost of supplying one unit from a specific place to another place . for e.g. C11 is the cost of supplying one unit of a commodity from S1 to D1.
Xij is the quantity being supplied from one place to another. For e.g. X11 is the quantity that is being supplied from S1 to D1.
Am is the maximum quantity that can be supplied from a specific place and Bn is the quantity demanded by a particular place.
The purpose of this study is to analyse the optimal transportation cost that Shri Mahavir Group occurs for transporting wheat across various destinations. For this, we've taken 6 destinations where the Mahavir group is a major supplier, with the assumption that the supplier wants to maximize its profits and consumers has the goal of obtaining a desired amount of wheat at the lowest cost possible.
To get the optimal transportation cost, first we're supposed to find an initial basic feasible solution, which can be calculated by the following methods -:

a) NWCR (North – West corner rule): The North-West Corner Rule is a method adopted to compute the initial feasible solution of the transportation problem. The name Northwest corner is given to this method because the basic variables are selected from the extreme left corner.

b) LCM (Least cost method): The Least Cost Method is another method used to obtain the initial feasible solution for the transportation problem. Here, the allocation begins with the cell which has the minimum cost. The lower cost cells are chosen over the higher-cost cell with the objective to have the least cost of transportation.

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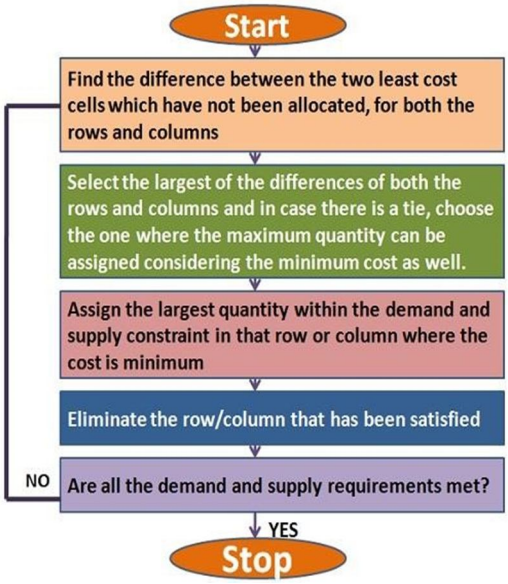
c) *VAM (Vogel's Approximation Method):* The Vogel's Approximation Method or VAM is an iterative procedure calculated to find out the initial feasible solution of the transportation problem. Like Least cost Method, here also the shipping cost is taken into consideration, but in a relative sense.

The following is the flow chart showing the steps involved in solving the transportation problem using the Vogel's Approximation Method:



After obtaining the initial basic feasible solution we'll use MODI (modified distribution) method to get the optimal transportation cost of supplying wheat of Shri Mahavir Group across the selected destinations.

2) *Modified Distribution Method*: The modified distribution method, also known as MODI method or (u - v) method provides a minimum cost solution to the transportation problem.

Steps in Modified Distribution Method (MODI)

a) Determine an initial basic feasible solution using any one of the three methods given below:

i) North West Corner Rule
ii) Matrix Minimum Method
iii) Vogel Approximation Method

b) Determine the values of dual variables, u_i and v_j, using $u_i + v_j = c_{ij}$

c) Compute the opportunity cost using $c_{ij} - (u_i + v_j)$.

d) Check the sign of each opportunity cost. If the opportunity costs of all the unoccupied cells are either positive or zero, the given solution is the optimal solution. On the other hand, if one or more unoccupied cell has negative opportunity cost, the given solution is not an optimal solution and further savings in transportation cost are possible.

e) Select the unoccupied cell with the smallest negative opportunity cost as the cell to be included in the next solution.

f) Draw a closed path or loop for the unoccupied cell selected in the previous step. Please note that the right angle turn in this path is permitted only at occupied cells and at the original unoccupied cell.

g) Assign alternate plus and minus signs at the unoccupied cells on the corner points of the closed path with a plus sign at the cell being evaluated.

h) Determine the maximum number of units that should be shipped to this unoccupied cell. The smallest value with a negative position on the closed path indicates the number of units that can be shipped to the entering cell. Now, **add** this quantity to all the cells on the corner points of the closed path marked with plus signs, and **subtract** it from those cells marked with minus signs. In this way, an unoccupied cell becomes an occupied cell.

We used TORA software to obtain the initial basic feasible solution by all the methods and optimal solution by MODI method.

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IV. DATA ANALYSIS

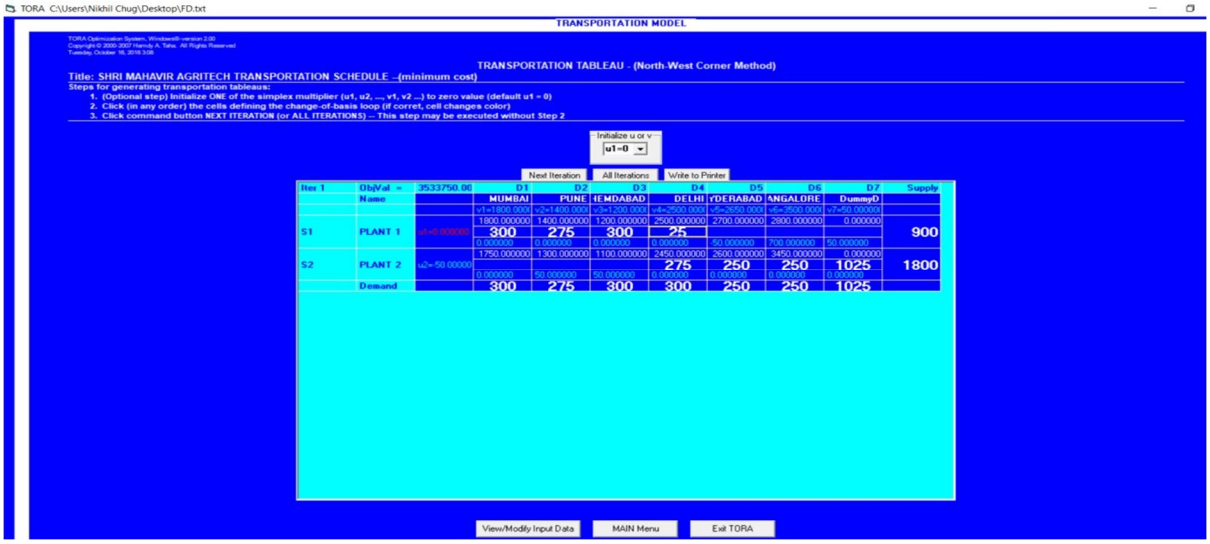
The following is the transportation schedule for Shri Mahavir Agritech :

	Mumbai	Pune	Ahmedabad	Delhi	Hyderabad	Bangalore	Supply
plant 1	1800	1400	1200	2500	2700	3500	900
plant 2	1750	1300	1100	2450	2600	3450	1800
Demand	300	275	300	300	250	250	

A. Cost In Per Metric Ton Quantity In Metric Tons

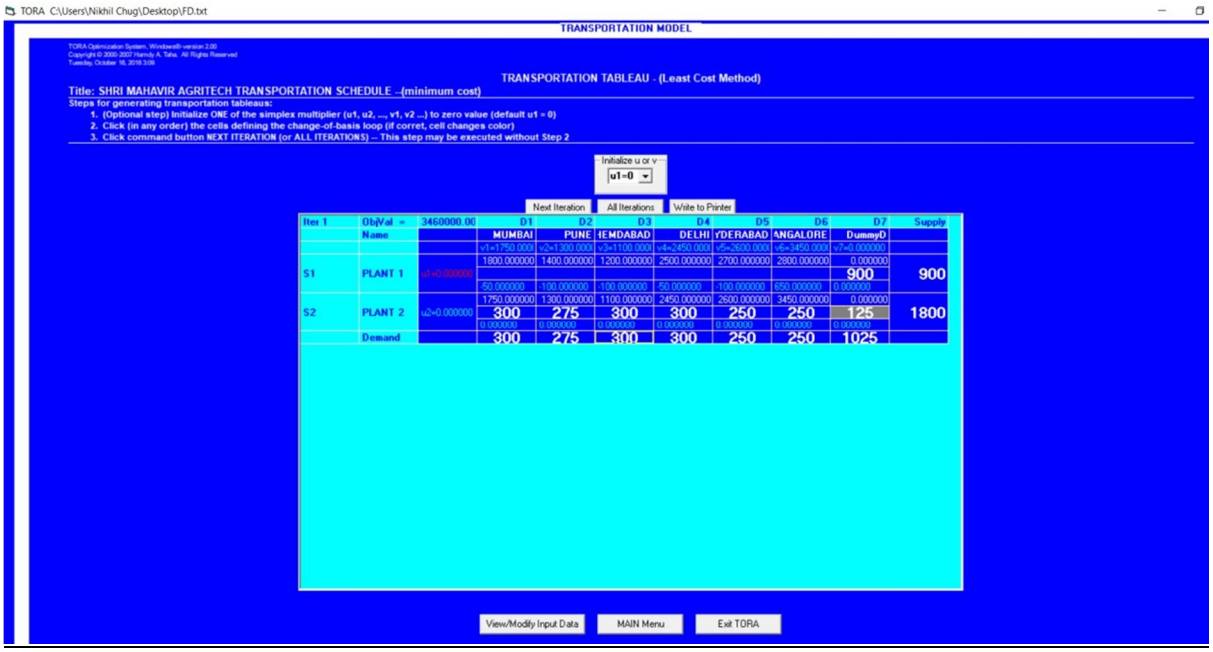
1) Solution: We used TORA to get the basic initial feasible solution using North-West Corner Rule , Least Cost Method and Vogel's Approximation Method and also to get optimal solution using MODI method.

a) North-West Corner Rule: We obtained the following solution using the North-west corner rule in TORA :



Where ObjVal represents the initial basic feasible cost using North-West Corner rule which is ₹35,33,750.

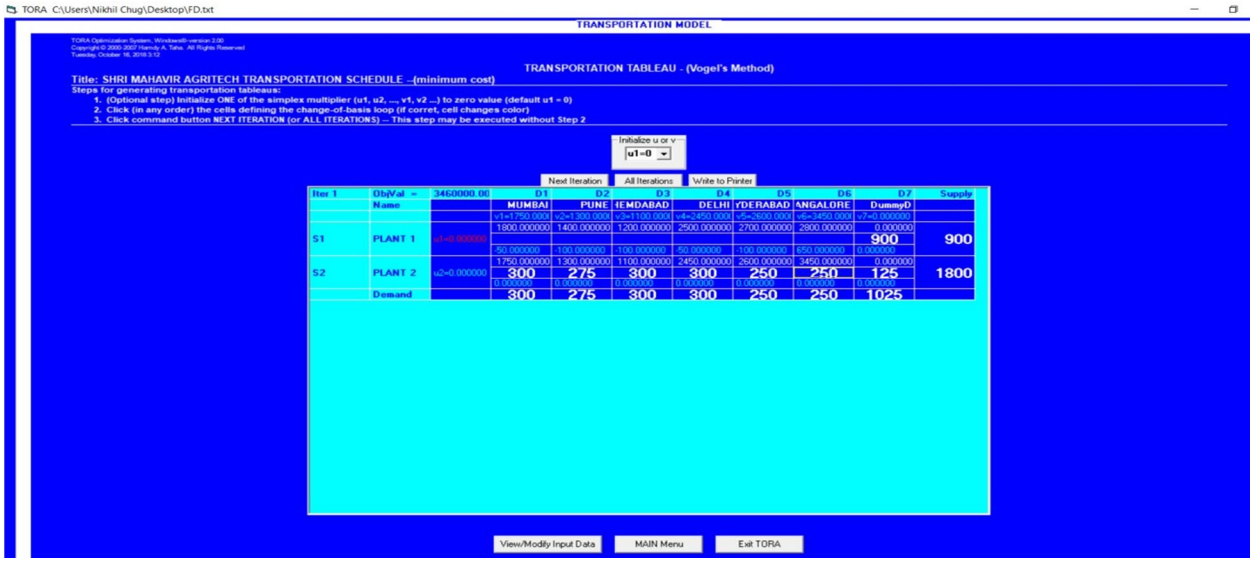
b) Least Cost Method: We obtained the following solution using the Least cost method in TORA.



Where ObjVal represents the initial basic feasible cost using least cost method , which is ₹34,60,000 .

c) Vogel's Approximation Method

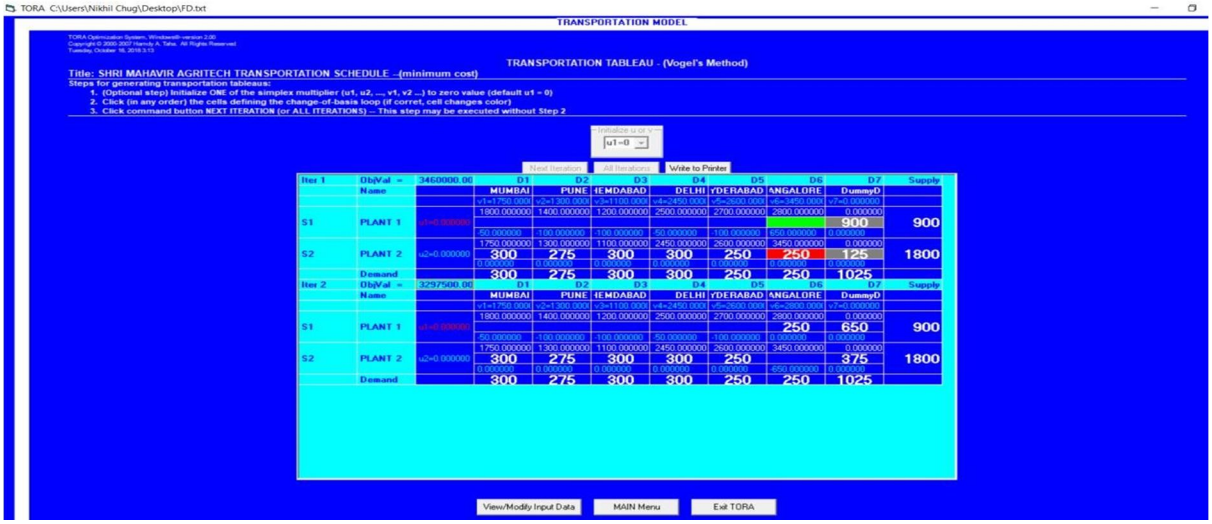
We obtained the following solution using Vogel's approximation method in TORA.



Where ObjVal represents the initial basic feasible cost using least cost method, which is ₹34,60,000.

d) Modified Distribution Method

We obtained the following solution Modified distribution method in TORA.



The Object value of Iter2 represents the optimal minimum cost of transporting, which is ₹32,97,500 and Iter 2 represents the optimal transportation schedule for the company. The change in allocations from S246 To S1D6 represents the looping in the problem.

V. CONCLUSION

This paper presents a study about how transportation algorithm can be used by the wheat producer, which is developed and implemented based on a mathematical model to find an optimal solution for transportation problem for minimizing cost and finding the most profitable transportation route. The algorithm has facilitated and reduced the complicated calculations. Thus, the use of software TORA has allowed us to save time and effort that manual solutions would consume. We calculated the basic initial feasible cost using North-

West Corner Rule, Least Cost Method & Vogel's Approximation method and the optimal minimum cost using the Modified Distribution Method.

These results would provide Shri Mahavir Agritech an appropriate advice on the ability to export the wheat at the lowest possible cost, therefore the price can be reduced to consumers, and then increased profits for these companies. Hence, they could increase or decrease the production quantities. The proposed solution needs to be improved in terms of correctness and scalability. Different cases of transportation problems might be taken into account to study the validation and expandability of the algorithm and its implementation.

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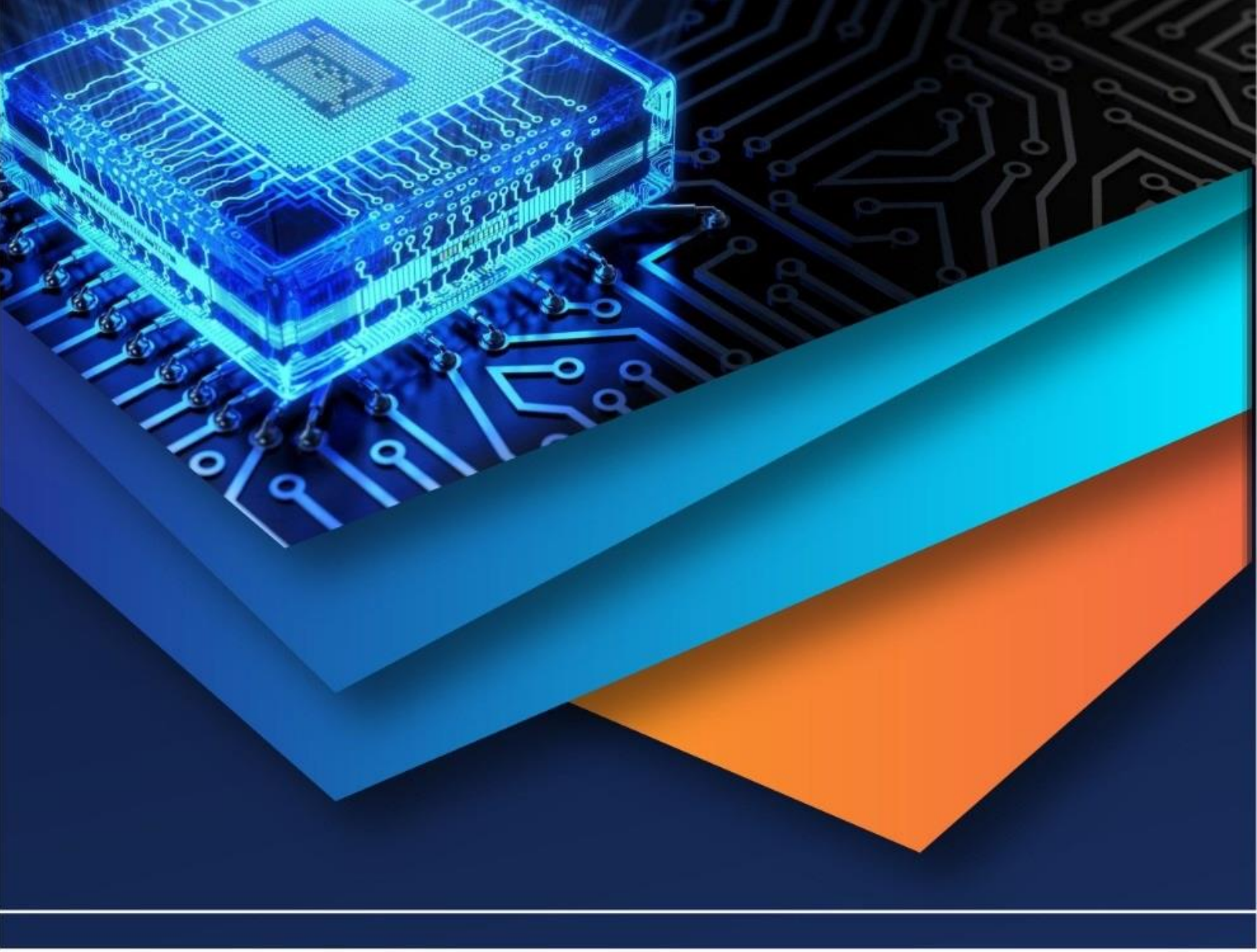

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