Vehicle Route Problem Solving in Manufacturing Firms

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Abstract—Nowadays small & medium scale industries are facing certain problems in Ethiopia, resulting time to delivery issues, high cost of transportation. This paper focused on elimination of transportation waste between firm to distributor, customer. Using Clarke Wright Savings method optimized the transportation time and distance between firm to distributor, customer. Failure mode effect analysis helped for identified the major non valve added activities (Transportation waste).

Key words: FMEA, Clarke Wright, VRP

I. INTRODUCTION

Time to pick up and delivery are major challenges in Ethiopian firms today environment. To meet these challenges many companies areresearching to improve their ability to competeglobally. Transportation Waste is one of Muda waste. This is because of,non-standardize vehicle routing, poor fleet management. This will lead to increase in time to pick up and delivery issues.Using FMEA technique identified the increasing customer service time. FMEA is an Engineering techniques used to define, identify and eliminate known failures, problems, errors which occur in the system, design, process and service before they reach the customer. The method was used as a technique of reliability assessment in order to determine the effects of disturbances and management. FMEA also known as risk analysis is a preventive measure to systematically display the causes, effects and possible actions regarding observed failures.

The Vehicle Routing Problem (VRP) is finding the optimal routes of delivery or collection from one or several depots to a number of cities or customers, while satisfying some constraints. A route is a sequence of visited customers for a certain vehicle, and starts and ends at the depot. A customer is an entity that has a certain demand and therefore requires the presence of a vehicle, a unit that can move between customers and the depot, a unit that initially possesses the demands of the customers. The goal of the Vehicle Routing Problem is to serve all customers, minimizing the total cost of the routes of all vehicles. The VRP has drawn enormous interests from many researchers during the last decades because of its vital role in planning of distribution systems.

The first savings heuristic was developed by Clarke and Wright. Among them, the Clarke and Wright savings heuristic (CW) is one of the most popular: CW is simple, easy to implement, very fast and obtains quite good solutions CW is based on merging tours according to a savings formula, which refers to the distance or cost saved by the merged route instead of having the two original ones. Since CW was introduced, several enhancements to the original savings formula have been proposed.

II. LITERATURE REVIEW

Generalization of the multi-depot capacitated vehicle routing problem where the assumption of visiting each customer does not hold. The Multi-Depot Covering Tour Vehicle Routing Problem (MDCTVRP), the demand of each customer could be satisfied in two different ways: either by visiting the customer along the tour or by “covering” it. When a customer is visited, the corresponding demand is delivered at its location [1] Multi-attribute vehicle routing problem derived from a real-life milk collection system. Problem is characterized by the presence of a heterogeneous fleet of vehicles, multiple depots, and several resource constraints. A branch-and-price methodology is proposed to tackle the problem. In this methodology, different branching strategies, adapted to the special structure of the problem, are implemented and compared. [2]

Vehicle Routing Problem with Backhauls is a pickup/delivery problem where on each route all deliveries must be made before any pickups. A two-phased solution methodology is proposed. In the first phase, a high quality initial feasible solution is generated based on spacefilling curves. In the second phase, this solution is improved based on optimization of the subproblems identified in a mathematical model of the problem [3]. Pickup and delivery of full truckloads under time window constraints. The objective function is to minimize empty vehicle movements, as these use resources without directly adding value to the products transported. First give an exact formulation of the problem. After that a relaxed problem formulation based on network flows, which can be used to calculate a lower bound to the solution value. Furthermore, here propose four different savings based heuristics for the problem. The results show that these heuristics find very good solutions quickly [4]. It explained consider the Asymmetric Capacitated Vehicle Routing Problem (ACVRP) a particular case of the standard asymmetric Vehicle Routing Problem arising when only the vehicle capacity constraints are imposed. ACVRP is known to be NP-hard and finds practical applications. In this paper describe the extension to ACVRP of the two well-known Clarke-Wright and Fisher-Jaikumar heuristic algorithms. It also propose a new heuristic algorithm for ACVRP that, starting with an initial infeasible solution [5].

FMEA for cost-effective, time-saving and easy-to-use failure modes and effects analysis (FMEA) system applied on the quality control of supplied products. The traditional FMEA has been modified and adapted to fit the quality control features and requirements. The paper introduces a new and revised FMEA approach, where the “ failure concept” has been modified with defect concept [6]. The paper investigates a class of extensions to the vehicle routing problem. A central focus of the paper is on the assumptions generally made in the literature and on the benefits of not making too restrictive assumptions. Research issues novel problem classes are highlighted. An Integer Linear Programming (ILP) formulation is also presented. It is also shown how this formulation can be adapted to cater for other problem versions. This paper also discusses various solution methodologies including.
meta-heuristics to solve the models and what more is needed the vehicle routing problem[7]. An effective hybrid approach that combines domain reduction with the Clarke and Wright algorithm to solve the capacitated vehicle routing problem. The hybrid approach is applied to solve 10 benchmark capacitated vehicle routing problem instances. The dimension other instances was between 21 to 200 customers. The results show that domain reduction can improve the classical Clarke and Wright algorithm by about 18%. The hybrid approach improves the large instances significantly in comparison with the smaller size instances. This paper will not show the time taken to solve each instance, as the Clarke and Wright algorithm and the hybrid approach took almost the same CPU time [8] Various reliability engineering and risk assessment techniques are applied to improve the blast furnace safety to prevent the blast furnace workers from accidents. This paper aims to provide the necessity of risk assessment techniques for implementing safety in an integrated steel plant[9]. FMEA method (Failure Modes and Effects Analysis), which is widely used in motor vehicles industry, can be improved and later used during certain stages of vehicle life cycle. A great deal of attention has been paid to risk analysis and the implementation of this parameter into the FMEA method, at the same time insisting on the inconsistencies of the traditional method. [10] Failure Mode and Effects Analysis (FMEA) for improving the reliability of sub systems in order to ensure the productivity which in turn improves the bottom line of a manufacturing industry. Thus the various possible causes of failure and their effects along with the prevention are discussed in this work. Severity values, Occurrence number, Detection and Risk Priority Number (RPN) are some parameters, which need to be determined[11]. It discussed supply chain management involves the efficient integration of suppliers, manufacturers, distributors, customers. Logistics and transportation cost plays a crucial role in the field of supply chain network planning and coordination. The logistics and transportation planning in customer side of the supply chain is generally referred distribution planning. Hence many works are carried out in this area to minimize the overall transportation cost through optimizing the transportation route and there by reducing the travel time too.[12]

III. PROBLEM DEFINITION

Firm was sending the finished goods to many areas through nonstandard routes This was creating time to delivery issues. Impact of Vehicle Route Problem (VRP) made increased lead time. This was affected customer service. The FMEA tool helped to pinpoint this transportation problem in supply chain. In this paper focus on the vehicle routing problem (VRP). A certain type of product is distributed from a plant to N customers, using a single vehicle, having a fixed capacity Q.

IV. METHODOLOGY

The Methodology of this Paper described in Fig 1. In the Investigation from the Industry Time to Delivery of the Finished product has been selected for the general Problem.

FMEA Method was adopted for finding Root Cause. The Vehicle Routing is the Root Cause of the delay of supply for finished product. Clark Wight Procedure proposes for finding optimum Root.

![Fig. 1: Methodology](image-url)

V. ROOT CAUSE IDENTIFICATION BY FMEA

FMEA is a systematic procedure enabling designers to identify potential failures, evaluate, investigate and take action to prevent. Here Risk priority number (RPN) is established for each cause of failure. This study was selected based on its history in Transport management and accessibility of data. This Result describes the Transport System of FMEA for the delivery of finished product. Specifically, Vehicle Routing Problem focused. The whole Transportation process is divided into various sub-processes that need to be evaluated. The RPN value has been evaluated for all the sub system in the Table 1.

![Fig. 2: Cost Saving Route Map Drawn By using Google Default Locations](image-url)

VI. CLARK WIGHT METHOD

Matrix is formed based on customer service locations. Matrix shows vehicle visiting n customers. Matrix shown in Fig 2. The vehicle starts at one city and must visit each of the other n-1 cities exactly once and then return to the original city. The cost of traveling from city i to city j is given as c_{ij} for all pairs of cities. The problem is to design a route of minimum cost that visits each of the n cities exactly once. If the cost to travel from city i to city j equals the cost to travel from city j to city i, (c_{ij}=c_{ji}) for all cities, then the problem is symmetric. If c_{ij}≠c_{ji} for some pair of cities, then the problem is asymmetric.
Designing a route of minimum cost has been computed by using clark wright saving method. origion of final goods stars from city ‘k’. The saving calculated based on $S_{ij} = \min(C_{ik} + C_{kj})$ for $i=1,2,..n; j=1,2,..n; i\neq k, j\neq k$.

For sample saving calculation $S_{12} = C_{10} + C_{02} = (571 + 231) - 333 = 469$. Order the saving value based on largest to smallest value. Before designing of route the saving order has been arranged from largest to smallest. $S_{78}, S_{18}, S_{16}, S_{68}, S_{15}, S_{58}, S_{56}, S_{17}, S_{67}, S_{12}, S_{25}, S_{26}, S_{28}, S_{75}, S_{34}, S_{32} , S_{24}, S_{35}, S_{36}, S_{37}, S_{38}, S_{45}, S_{46}, S_{47}, S_{48}, S_{44}, S_{47}, S_{48}, S_{56}, S_{57}, S_{58}, S_{67}, S_{68}, S_{79}$. Finally the actual locations of customer service drawn from satellite map. Based on a feasible route that cities i and j were linked, route map shown in fig 2.

VII. RESULT AND DISCUSSION

FMEA clearly pinpointed transportation (MUDA) waste made increasing service time, cost. Root cause of the problem was finalized vehicle route mapping graph is drawn between before and after using Clark wright method shown in fig 3. It shows service time is reducing by follow the standard vehicle route map.

![Fig. 3: Service Time Comparison](image)

VIII. CONCLUSION

FMEA method helped to identified the problem clearly. Evaluation of FMEA with Industry Vehicle Routing Problem sorted. Clerk wright method has been followed for solving vehicle Routing. The method has produced encouraging result for Vehicle Routing. From proposed new method of Vehicle Routing Lead Time and Transportation cost has been reduced and fleet management of the Industry became standardized. The all effects due to proposed Vehicle routing will lead to increase the sales of Industry and Profit.

REFERENCE


IX. FAILURE MODE EFFECT ANALYSIS

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<table>
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<tr>
<th>Vehicle</th>
<th>Vehicle for Transportation between firm and customer</th>
<th>Improper Route Followed</th>
<th>Service</th>
<th>9</th>
<th>Non Standard Vehicle Routing</th>
<th>6</th>
<th>Existing Routing System</th>
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<td>Planning for Pickup and Delivery the Items</td>
<td>Delay of Supply</td>
<td>Affect of Customer Reliability</td>
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<td>Availabilities of Different Routes</td>
<td>Lead Time and Cost Increased</td>
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Table 1:

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Table 2: Clark Wight Matrix Done By Distance