Delivery Vehicle's Simultaneous Delivery and Pickup Routing Problem in an E-commerce Environment

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Abstract --Vehicle's simultaneous delivery and pickup routing problem in E-commerce environment is addressed. When a real-time pickup order is received, it is difficult dealing with the discrepancy between logistics cost and timeliness of service for the company. A dynamic scheduling strategy is developed to designate real-time requirements utilizing on-delivery vehicle quickly and in cost effective way. Firstly, preprocess dynamic pickup orders and determine the scheduling time, which would translate the dynamic demand problem to serial static problems; Secondly, an improved PFIH algorithm is developed to insert the pickup requirements into existing routes and generate the optimized routes; Finally, with the help of 2-opt method and relocation method, all unserved pickup requirements are readjusted and reoptimized by the improved PFIH algorithm again. The designed algorithm can insert new pickup requirements into the routes of on-delivery vehicles, and reoptimize the optimized routes effectively with the newly inserted requirements.

Keywords: Simultaneous Delivery and Pickup, scheduling time, PFIH algorithm, 2-opt method

I. INTRODUCTION

The Vehicle's Simultaneous Pickup and Delivery Routing problem with is a variation of conventional VRP. And it is extension of Vehicle Routing Problem (VRP). This problem eliminates the drawback of delivering and pickup requirements. It considers the delivery and pickup procedure as entirely single process. As a result, it reduces the empty load ratio of vehicles in the transport journey or return journey and improves vehicle transportation efficiency. Customers have increasing pickup requirements with the improvement of E-commerce [7]. Nearly all customers needs the company to offer very fast and better logistics service for them. This form of dynamic Vehicle routing problem with dynamic demand is very much towards the real world environment that it has emerge gradually as research hotspot.

In the study, vehicles may swap some of their transport requests, some specific requests can be served by different vehicles while reserved requests will be processed by themselves; customer's time windows are divided into stages, classification is based on whether customers can be deferred and customers that cannot be delayed with respect to demand attributes in each stage.A dynamic closed-loop VRP with undetermined pickup and determined delivery of inappropriate goods is checked, a solution method by referring the variable neighbourhood search is designed for solving the VRPSPD [5].

The Vehicle Routing Problem (VRP) is one of the Operations Research's building blocks, where one wants to determine plan with least costing to deliver products from a storehouse to customers while satisfying sets of practical constraints. Usually, total travelled distance is an approximate measure for cost defined in the objectives-function of most VRPs, and their variants. For oil and gas exploration companies, including the case study company, crew transportation problems are solved daily as they need to send engineers and maintenance personnel from living quarters, located somewhere on the ocean, to several scattered platforms by a limited number of capacitated crew boats [5]. Typically, these decisions are made by seasoned route planners with little help of any support systems.

II. LITERATURE SURVEY

The VRP becomes evident in retail distribution, routing the school buses, courier and newspaper's delivery, railway fleet and airline fleet's schedule and routing. It is a known and combinatory and complicated problem with considerable economic significance. Involving serving the consumers with specific time window using many vehicles that vary with respect to the problem, thus the VRP is more complete. The heuristic and meta heuristic methods produces the optimal or a very near to the optimal solution in a fair quantity of processing time [7] .

2.1 Heuristics Vehicle Routing Problem using Time Window

Most of the available heuristic searching methods include finding first possible solution and then bettering on that selected solution using local or global optimization strategies. In this case, the push forward insertion heuristic (PFIH) is being used, which is a way to create first mute configuration. PFIH is competent technique to insert customer in new routes.

The technique selects the edge that has the lowest additional insertion cost. The possibility test, checks all constraints which includes time windows and the load holding ability. Only feasible insertions will be accepted. When currently selected mute gets full, PFIH starts fresh route and replay the procedure until all customer arc are routed. VRPTW is an efficient technique to obtain possible solutions.

2.2 Multi-Objective Vehicle Routing Problem with Time Windows

The vehicle routing problem (VRP) is an operation related decision making problem for the delivery of parcels from a storehouse to customers using a huge group of vehicles. The vehicle routing problem with time windows (VRPTW) is further improvement of the VRP with latest servicing time for consumers and the time of travel. This project proposes algorithm with multiple objectives that includes a heuristic, local search and a meta-heuristic for solving the multi-objective optimization in VRPTW. The limitations to the problem are servicing all the consumers with earliest and fast service time of consumer not to exceed the route timing of vehicle and overloading. The route timing of vehicle is the total sum of pending time, the total servicing time and traveling time. The total of the customer demands in one route will not be greater than the overall capacity of vehicle.

2.3 The Traveling Salesman problem

A salesman need to travel from a city to other cities exactly once for selling his goods and return to the initial city. This is to be done along with covering the least total distance. Solution methods of TSP is as follows

Brute forcing method

The brute-forcing method generates all feasible tour paths and calculates their distances. The tour with the shortest path is an optimal path. Solving TSP using Brute-forcing method we can use the following steps:

- **Branch and Bound method**

This technique will divide problem in a no. of small sub-problems, being a method for solving sequence of sub-problems everyone of them may possess many feasible solutions and where chosen solution for a sub-problem might affect the feasible solutions of following sub-problems.

III.EXISTING SYSTEM

Variable Neighbourhood Search Approach for Crew Transportation Problems

The Vehicle Routing Problem (VRP) is one of the Operations Research's building blocks, where one wants to determine plan with least costing to deliver products from a storehouse to customers while satisfying sets of practical constraints.However, this typical distance-based objective does not reflect the implicit cost of waiting, when valuable human resources, with limited working hours, are transported to number of different destination. In such a case, a traditional least cost plan may be an inefficient one as those human resources may not finish their tasks within the remaining working period — resulting in a project delay. Thus, both total travelled distance and man-hour loss should be recognized and modelled simultaneously in the planning phase of this so-called crew transportation problem. For oil and gas exploration companies, including the case study company, crew transportation problems are solved daily as they need to send engineers and maintenance personnel from living quarters, located somewhere on the ocean, to several scattered platforms by a limited number of capacitated crew boats [5] . Typically, these decisions are made by seasoned route planners with little help of any support systems.

IV. PROBLEM STATEMENT

Problem : Vehicle Routing Problem in E-Commerce Environment The vehicle routing problem (VRP) is an operational decision problem for the delivery of parcels from a the storage location to the customers using group of vehicles ,where one wants to determine plan with less cost to deliver products from a storehouse to customers while satisfying sets of practical constraints. The aim is reducing the no. of vehicles and the total travel time to service the customers while also keeping in check the transportation cost (fuel cost) [5] .

V.PROPOSED SYSTEM

The system proposes a vehicle's simultaneous delivery and pickup routing problem with in E-commerce environment. When receiving a real-time pickup order, it is hard to deal with the contradiction between logistics cost and timeliness of service for express company. A dynamic scheduling strategy is developed to allocate real-time requirements utilizing on-delivery vehicle economically and quickly. Firstly, pre-process dynamic pickup orders and determine the scheduling time, which can translate the dynamic demand problem to series of static problems; Secondly, an improved PFIH algorithm is developed to insert the pickup requirements into existing routes and generate the optimized routes. The example shows that the designed algorithm can insert new pickup requirements, and reoptimize the optimized routes with new inserted requirements effectively.

Working of Algorithm

Steps:

1. Dynamic demand Preprocessing
2. Real-time optimization

1. Mathematical Model

Notation of the parameters and variables :

I_w Set of unfinished requirements of customers

I_u Set of new customers, $I_u \subset I_w$

I_θ Set of virtual customers(on delivery vehicles)

K_θ Set of delivery vehicles when scheduling starts

K_o Set of vehicles in DC when scheduling start

K set of vehicles, $K_o + K_\theta = K$

c_1 *Travel cost coefficient of vehicles*

c_2 Departure cost(fixed cost)coefficient of vehicles

c_3 Punishment coefficient when the vehicles arrive at customer I_i before ET_i

c_4 Punishment coefficient when the vehicles arrive at customer I_i before LT_i

ET_i Earliest allowed start service time of customer I_i

LT_i Latest allowed start service time of customer I_i

at_i Arrival time at customer I_i

wt_i Waiting time when arriving at customer I_i before ET_i

t_{ij} Travel time I_i to I_j

d_{ij} Distance from I_i to I_j

$$\text{Minz} = c_1\left(\sum_{i=1}^{I_\theta}\sum_{j=1}^{I_w}\sum_{k=1}^{K_\theta} d_{ij}x_{ijk} + \sum_{j=1}^{I_w}\sum_{k=1}^{K_\theta} d_{oj}x_{ojk}\right) + c_3\sum_{i=1}^{I_w} max(ET_i - at_i, 0) + c_4\sum_{i=1}^{I_w} max(at_i - LT_i, 0) + c_2\sum_{j=1}^{I_w}\sum_{k=1}^{K_o} x_{ojk} \quad .....(1)$$

$$\sum_{k=1}^{K}\sum_{j=1}^{I_w} x_{ijk} = 1, i \in I_\theta \cup I_w \cup I_o \quad (2)$$

$$\sum_{k=1}^{K}\sum_{i=1}^{I_\theta \cup I_w \cup I_o} x_{ijk} = 1, j \in i_w \quad (3)$$

$$at_j = at_i + wt_i + s_i + t_{ij} wt_i = max\,(ET_i - at_i, 0) \quad (4)$$

$$\sum_{j=1}^{I_w}\sum_{k=1}^{K_o} x_{ojk} \leq n_o \quad (5)$$

$$n_o + n_\theta = k \quad (6)$$

$$x_{ijk} = \begin{cases} 1 & if\ vehicle\ k\ travels\ from\ I_i\ to\ I_j \\ 0 & Otherwise \end{cases}$$

$$i \in I_\theta \cup I_w \cup I_o, j \in i_w, k \in K_o \cup K_\theta \quad (7)$$

Formula (1) is the objective function, the aim is to reduce traveling cost, fixed cost of vehicles and time penalty cost; constraint (2) and (3) make sure that every customer can only serviced by one vehicle and be served only once. Constraint (4) is the computing method of arrival time and waiting time; Constraint (5) indicates that the no. of vehicles departing from DC can't exceed the total vehicles waiting in DC; Constraint (6) limit of total no. of vehicles, respectively, is the no. of vehicles waiting in DC, is the number of on-delivery vehicles.

2. System Architecture

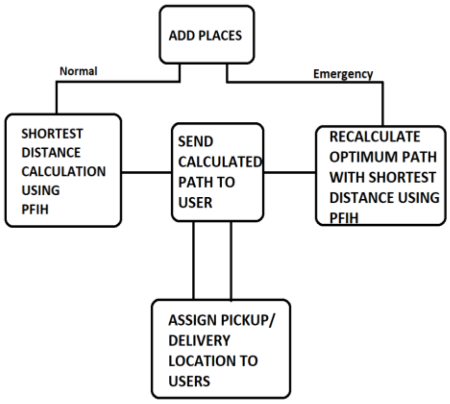

Fig 1: System Architecture

Add Places

Input is given from admin of the system which is stored in the application for further processing of optimal path calculation.

Calculated Path

Input from admin is used to calculate new optimal path for given pickup/delivery locations. The PFIH algorithm is used for calculating optimal path.

Adding Emergency Location

Dynamically adding a new pickup/delivery location to already present list of location is achieve. After adding the new location, system recalculates new optimal path taking into consideration user's location and availability.

Insertion Heuristic (PFIH)

Insertion Heuristic Algorithm is used for assigning vehicles to orders that are already evaluated and finalized by the system.

VI. RESULT AND DISCUSSION

INPUT

Admin logs in to the android application and enters starting place and next places. After clicking on Submit and then Path button, optimal path is created and stored on the server.

PROCESSING

The path entered as input by admin is used in PFIH algorithm, the optimal path is calculated taking into consideration the user's location and availability of the network. This process is done again after admin adds an emergency path too. The resultant optimal path is stored on the server and then can be retrieved by the users of the application.

OUTPUT

User logs in and when click on Click Here Button, the optimal path that is calculated by the system is shown along with respective distances between the two locations.

Table no1: Comparative Study

Heuristics Vehicle Routing Problem using Time Window	Multi-Objective Vehicle Routing Problem with Time Windows	The Traveling Salesman problem
1. In Heuristics Vehicle Routing Problem using Time Window the push forward insertion heuristic (PFIH) is used	1. The vehicle routing problem with time windows (VRPTW) is an extension of the VRP with earliest, latest, service times for customers and travel times	1. The Traveling Salesman problem has two approaches i)Brute-force method. and ii)Branch and Bound.
2. PFIH gives a reasonably good feasible solution in terms of the number of vehicles used	2. This proposes a multi-objective algorithm that incorporates a heuristic, local search and a meta-heuristic for solving the multi-objective optimization in VRPTW	2. The solution to any given TSP would be the Shortest way to visit a finite number of nodes, visiting each node only once, and then returning to the starting point.
3. The implementation of λ – interchange is a basic cornerstone for more complex Heuristic Algorithm.	3. The modelling of VRPTW aims to optimize a multi-objective problem by using the hybrid algorithm.	3. In Travelling Sales Person Problem we arrive at the optimized solution from the approximate solution obtained from various approximation techniques

VII. CONCLUSION

Hence the above paper is basically for the logistic company who want to calculate optimum path, along with dynamic pickup and drop request in an e commerce environment .The capital aim of this paper is to reduce cost as well as travelling time of the delivery person. The re calculated path has the newly added emergency place along with old places all in optimized sequence. The algorithm used has a top accurate absolute amount for these situations where a new order is to be fulfilled in nearby area where delivery persons are already servicing. It is as well computed decidedly fast compared to other path finding algorithm.

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