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.

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. 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[7]. 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.

II. RELATED WORK

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.

III. 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]

3.1 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 procedure is simple and easy to follow. The technique tries inserting the consumer in middle of all edges in the currently available route. It 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. Usually, PFIH outputs a reasonable and better possible solution considering the no. of vehicles used. Initial no. of vehicles gives us an upper bound regarding no. of routes in solutions. PFIH plays important role of building the mute configuration for VRPTW [3]. It is an efficient technique to obtain possible solutions.

3.2 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. The aim here is to reduce the vehicles and the total travelling time to service the consumers by using an evolutionary hybrid algorithm.[7] 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 algorithm is developed modifying the push-forward insertion heuristic, λ-interchange local search descent method (λ-LSD) and tabu search (TS). The made route is based on MPFIH as primary solution which is further made better with the use of the λ-LSD and TS. 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. Vehicle reaching consumer prior to the earliest time, preceding latest time and later than the maximum route time acquires the waiting time and the overtime. The total of the customer demands in one route will not be greater than the overall capacity of vehicle.

3.3 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 [2]. This is to be done along with covering the least total distance. Solution methods of TSP is as follows:

• Brute forcing method.

• Branch and Bound method

Brute forcing method

Thinking of the TSP, the method to consider firstly is 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:

Step 1. Total no. of tours should be calculated.

Step 2. List different feasible tours.

Step 3. Distance of every tour is to be calculated.

Step 4. Optimal solution includes choosing the shortest path of tour.

- **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.

Step 1: Start node is selected.

Step 2: Bound is set to very huge value, for instance infinity.

Step 3: In between current and a node which is not yet visited the cheapest arc is selected and distance is added to the current distance and repeating the procedure until current distance has value lesser than the bound.

Step 4: If the bound is more than current distance , then everting is completed

Step 5: Sum of the bound and distance will equal current distance.

Step 6: step 5 is repeated until all the arcs are covered.

3.4 2-opt-based Heuristic Hierarchical Traveling Salesman problem

Heuristic for the HTSP is based on the 2-opt heuristic for solving a classic TSP. The priorities constraints which are in the HTSP must be enforced. Since finding a possible solution very near to the optimal solution in length will reduce no. of exchanges required to create first tour using two different techniques called "Sequential TSP" technique and "Giant TSP" technique [4]. Both are used to create candidate solutions. These solutions will be evaluated and compared and the one with the less total distance being chosen as heuristic solution. In Sequential TSP technique, the first tour is made by linking separate TSP heuristic solutions to different subsets of the set of nodes. For HTSP with constraint k, every (k + 1) priorities are in a group. Priorities 1 to (k+1) is single priority group, priorities (k+2) to (kd+2) are second priority group, total are p/(k+1) groups. Depot to each of the group is added and run the 2-opt heuristic for solving each as classical TSP problem. The TSPs are joined together to make a possible initial tour. The Giant TSP Method is started by the use of 2-opt heuristic to solve a classical TSP over the set of all nodes, which includes depot. At last, the last node to be included in the tour connection is made to depot for creating a possible initial tour Next, we use a modified 2-opt procedure to improve this initial tour. Finally, procedure is repeated five times and the best tour of the five is returned. This step aims to increase the quality of the results while runtime is increased by constant factor. [4]

IV. 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. [5] 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. Typically, these decisions are made by seasoned route planners with little help of any support systems..

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).

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

VRPSDP proposed in this project is described as follows A distribution center of express company receives customers' pickup demands in real time. According to quantity of received requirements and time interval between two adjacent scheduling programs, the start time of scheduling t (n) would be determined, n is the sequenced number of scheduling in this day. Taking locations, time demands of on-delivery vehicles and new pickup customers into account, these requirements are pushed into current routes of on-delivery vehicles under the premise of meeting all customers' time demands. As for new requirements that can't be inserted, it would be accepted by vehicles waiting in DC. A set of possible routes can be found by reducing cumulative delivering and picking up costs. This project assumes that the locations, time windows of DC and delivery customers are known, and new pickup customers' are unknown. Weight and volume of expresses are light and small normally, so this project wouldn't consider vehicle weight and volume constraints.

Notation of the parameters and variables :

Set of unfinished requirements of customers

Set of new customers, ⊂

Set of virtual customers(on delivery of delivery vehicles when scheduling starts

Set of vehicles in DC when scheduling start

K set of vehicles,+ = 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 vehicles) Set

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

min.z =

$c1(\Sigma\Sigma\Sigma dijxijk+K\theta k=1Iwj=1I\theta i=1\Sigma\Sigma dojxojkK\theta k=1Iwj=1\ )+c3$

$\Sigma ma(ETi-ati,0)+ Iwi=1c4\ \Sigma max(ati-LTi,0)Iwi=1+c2\ \Sigma\Sigma xojkKok=1Iwj=1$ (1)

$\Sigma\Sigma xijk\ Iwj=1=1,\in Kk=1I\theta\cup Iw \cup Io$ (2)

$\Sigma\Sigma xijk\ I\theta\cup Iw \cup Io\ i=1Kk=1= 1, j \in iw$ (3)

$atj=ati+wti+si+tijwti=max(ETi-0)$ (4)

$\Sigma\Sigma xojk \leq noKok=1Iwj=1$ (5)

$no+n\theta=k$ (6)

$xijk = \{\ 1\ if\ vehicle\ k\ travels\ from\ Ii\ to\ Ij0\ Otherwise$

$i\in I\theta\cup Iw \cup Io, j \in iw, k\in Ko\cup K\theta$

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, is the total no of vehicles; Formula (7) is the decision variable.

2. System Architecture

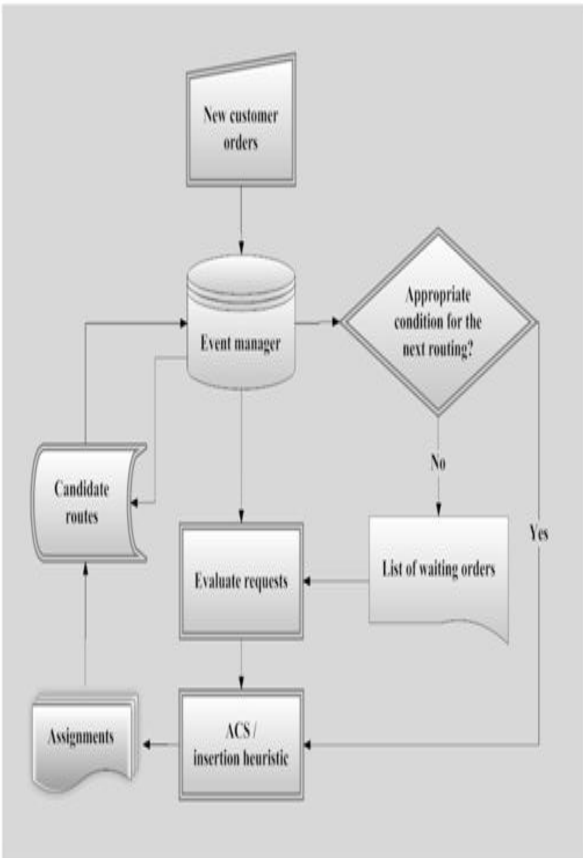

fig.7.3 System Architecture

New Customer Orders

Once a customer places a new order request either pickup or return order, then this request is logged in the New Customer Orders followed by forwarding it to Event Manager.

Event Manager

It is the database of the orders that are made by the users. It assists to calculate Candidate Routes and to help system evaluate the requests made by the customers. Decisions are made based on this event manager data for weather it is appropriate condition for next routing.

Candidate Routes

Candidate Route are the set of possible route , among them is an optimal route for current requests of the user. It assists the system to evaluate orders in conjunction with Event Manager Data. It then assigns the Vehicles for the requested Order.

Evaluate Requests

Data from the Event Manager is user to evaluate the requests made earlier , also it takes on account the list of Pending Orders. Consider both , waiting and current orders the system calculates the optimal path either including old waiting order or without it.

List of Waiting Orders

It maintains a list of order made earlier by the customers with are not yet executed . It helps the system in deciding the sequence of orders.In case two orders are in same area it schedules the order in proper sequence so as to save time and cost in term of fuel.

Assignments

It assigns the available vehicles to orders that are evaluated by the system. Insertion Heuristic method is used to manage the assignments of available Vehicles to the available orders at given time.

Insertion Heuristic

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

CONCLUSIONS

1]To solve the problem that delivery vehicles' transport capacity is wasted and new pickup demand can't be satisfied in time, this project studies vehicle routing problem of delivery vehicles in E-commerce environment.

2]This project adopts a dynamic scheduling strategy involving Dynamic requirements Preprocessing, Real-time requirements batch insertion and Real-time route re-optimization.

3]Firstly, the dynamic order is pre-processed to determine the time of batch scheduling; Then an improved PFIH algorithm is developed to optimize the route in real time, it inserts the pickup requirements into the current paths and generates optimized routes; finally, all unfinished requirements which have been inserted in current Scheduling period or before current scheduling period would be reoptimize by the improved PFIH algorithm again.

4]The improved algorithm inserts new pickup requirement into the route of on-delivery vehicle and reoptimize the optimized routes with new inserted requirements effectively.

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