

Preliminary Analysis of Dynamic Fleet Management Support System

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Abstract— *Vehicle routing plan is usually provide optimal or near optimal way to serving client which several constraint, such as delivery time windows. The dynamic fleet environment in city logistic has many unexpected events when delivery was executed. We will conduct a research to develop a near real time vehicle operation system support. The future result of this research is an intelligent dynamic fleet management support system. Architecture of system will consider integrating communication and positioning technology, decision support system module and data management. The system will monitor and accept report from delivery vehicle, adjusts routing plan and calculate total cost that affected. Evaluation for this system will use simulation environment and real case study.*

I. INTRODUCTION

Distribution cost typically is achieved to reduce total cost of logistics. Effort to minimize it will focus on distribution plans development using various vehicles routing algorithm. In particular, minimizing cost is achieved mainly by: (i) automatic dispatching support (including handling of unexpected events), (ii) dynamic transportation optimization in real-time, (iii) increased capacity utilization through optimized allocation of shipments to trucks, (iv) comprehensive integration of telematics services, (v) synergy effects through combination of different logistics network types, (vi) increased transparency and visibility throughout the network, (vii) Combination of different traffic types (round trip, linehaul meetings, multi-modal traffic) [1].

In dynamic fleet management, travel time data can be highly variable due to breakdowns, weather conditions and traffic jams [2]. Distribution plans execution often faces to unforeseen adverse these condition that will become unexpected costs. Zeimpekis [3] conclude there are 3 main types of such incident that will be act like as constraint in distribution execution:

- (i) Incident originating from the client served. (such as order cancellation, lack of unloading or parking space in client site).
- (ii) Incident related to the infrastructure and environment (such as traffic congestion, road construction).

- (iii) Incident related to the delivery vehicle.(such mechanical failure).

Distribution plans will not use relevant anymore and no means sufficient to address such unexpected events that may have affect to system performance. Monitoring vehicle using mobile and position technology are not designed to address for unforeseen events. In other case implementation these technology require high investment.

This research will focus on incident originating from client served such as new client requests appear during execution. Several assumption will use during system development. This system will have performance depends on validity of the assumption. Pre-feasibility study to develop this system that concludes several point [3], such as:

- (i) Existing real-time fleet management system can fulfil as subset of the requirement expressed by logistics and distributions organizations. There are 3 others requirements that met in existing system.
- (ii) Ability to reroute vehicle intelligently is delayed and miss delivery time windows.
- (iii) Ability to deal with vehicle breakdowns by rerouting another vehicle that has adequate load capacity and time availability to replace the immobilized vehicle function.

This paper is organized as follows; section 2 present information technologies for vehicle management, vehicle routing problem and solution approach, and framework decision system support latest issue. Section 3 present discussions and future work, and final section will conclude this paper.

II. LITERATURE REVIEW

A. Information Technology For Fleet Management

1) Electronic Trip Recorders

Electronic trip recorders are also known as onboard computers. These devices automatically monitor and record the performance of vehicles and drivers. Electronic trip recorders include a trip data display, speed and rpm audio alarms, a fuel consumption display, time of day, trip statistics and hours of service records. Furthermore, event data, discrete data and driver input can be recorded in protected areas of memory. A mobile communication system enables the driver

to transfer the information to a dispatcher in real-time. As a result, a dispatcher can monitor the vehicle/driver performance historically and in real-time, this reduces the administrative workload and improves vehicle diagnostics.

2) Two Ways Communication

A two-way radio is a radio that can both transmit and receive (a transceiver), unlike a broadcast receiver which only receives content. Two-way radios are available in mobile, stationary base and hand-held portable configurations. Hand-held radios are often called walkie-talkies or handie-talkies. A push-to-talk or Press To Transmit button is often present to activate the transmitter. A mobile phone or cellular telephone is an example of a two-way radio that both transmits and receives at the same time (or full-duplex). It uses two different radio frequencies to carry the two directions of the conversation simultaneously. The available systems on the market range from mobile phones and citizen band radios to digital broadcast systems depending on cost and sophistication. One example, Qualcomm's omniTRACS system allows the transfer of real-time data.

3) Automatic Vehicle Location

Automatics Vehicle Location System means for determining the geographic location of a vehicle and transmitting this information to a point where it can be used. Various alternatives are available to identify vehicle location relative to a map in real-time. The Global Positioning System (GPS), a current market leader, determines a user's worldwide location (latitude, longitude and altitude) by tracking signals from four or more satellites out of 24 satellites orbiting the Earth. The GPS can provide real-time position with accuracy within meters depending on the type of receiver and other conditions.

B. Problem and Solution

1) Travelling Salesman Problem

Classical and fundamental problem in fleet operation is the Traveling Salesman Problem (TSP). The goal of the TSP is to minimize the total travel distance when a salesman, starting from his home city, is to visit each city exactly once on a pre-specified list and then return home. This simple problem has gained importance because not only can it be extended for many applications including vehicle routing, facility location, and machine scheduling problems but its general solution algorithm can also be used to solve other problems of its genre: combinatorial optimization. In general, the combinatorial optimization problem cannot be solved by traditional differential calculus because the decision is to find a tour (sequence) instead of determining a continuous value. Except for the special form, for example a TSP with an upper triangular distance matrix (i.e. $c_{ij}=0$ if $i>j$), the TSP problem is a 'NP-hard' problem. An NP-hard problem is extremely unlikely to have a polynomial algorithm to solve it optimally

although it is not proved that the worst case exponential solution running times are unavoidable. The formal definition of NP-hard is as follows (according National Institute Standard and Technology):

"The complexity class of decision problems that are intrinsically harder than those that can be solved by a nondeterministic Turing machine (It is a "parallel" Turing machine which can take many computational paths simultaneously, with the restriction that the parallel Turing machines cannot communicate) in polynomial time. When a decision version of a combinatorial optimization problem is proven to belong to the class of NP-complete problems, an optimization version is NP-hard."

A mathematical Integer Programming (IP) formulation is presented before investigating the solution algorithms. Let x_{ij} be a binary variable, which indicates whether a salesman visits city j immediately after city i , and c_{ij} be the distance between the two cities (i and j). The objective function is to minimize the realized travel distance. The mathematical formulation of the TSP is similar to the assignment problems except for the subtour elimination constraint.

Jin [4] describes in his thesis, variations of TSP are:

Bottleneck TSP: The objective is to minimize the longest distance between cities rather than the sum of these distances, while a salesman travels all the given list of cities.

The time dependent TSP: The costs (distance) between cities change depending on the time when a salesman travels. The objective is the same as for the original TSP.

Probabilistic TSP (PTSP): The number of cities to be visited in each problem instance is a random variable where the probability that a subset of cities at an instance occurs is $P(S)$.

TSP with Time-windows (TSPTW): Each city has its own time-windows such that a salesman visits a city between the earliest and latest pickup time. This problem can be divided into two sub-problems: the TSP with hard time-windows and the TSP with soft time-windows. In the latter case, the time-windows may be violated but a penalty is then added to the objective function.

2) Vehicle Routing Problem

The vehicle routing problem (VRP) is a generic name given to a class of problems in which 'vehicles' visit 'customers' [4]. The deterministic and static version of the mathematical model that best describes certain aspects of the fleet management problem of interest falls in to this class. It seeks the efficient assignment of available vehicles to (known) demands, and the sequencing of the demands served by each vehicle, subject to various constraints.

This research will conduct vehicle routing problem with simultaneous pick-up and delivery is the problem of optimally integrating goods distribution, when no precedence constraints are imposed on the order in which the operations must be performed. The VRP with simultaneous pick-up and delivery (VRPSPD) [5] is the following problem: a set of customers is located on a transportation network; each customer i requires either a delivery or a pick-up operation (or both) of a certain

amount of goods and must be visited once for both operations. The service is provided by a set of vehicles of limited capacity Q ; each vehicle leaves the depot carrying an amount of goods equal to the total amount it must deliver and returns to the depot carrying an amount of waste equal to the total amount it picked-up. In each point along its tour each vehicle cannot carry a total load greater than its capacity. The goal is to minimize the overall length of the tours.

Classification of problem described by Assad [6] in the Table below:

TABLE I
GENERAL CHARACTERISTICS OF ROUTING PROBLEMS

Nature of Demand	Pure pickup or pure deliveries Pickups with backhaul option Single or multiple commodities Must serve all demands? Common carrier option Priorities for customers
Information on Demand	All demands known in advance? Many repeat demands Fixed frequencies for visits Uncertain demands Real-time inflow of demands
Vehicle Fleet	Homogeneous fleet or multiple vehicle types Weight and capacity restrictions Compartments Loading restrictions/equipment Vehicle type/site dependencies Vehicle type/commodity compatibility Fixed or variable fleet size Fleet based at single depot or multiple terminals
Crew Requirement	Pay structure: <ul style="list-style-type: none"> • length of workday • minimum and maximum on duty times • overtime option Fixed or variable number of drivers Driver start times and locations Lunch or other breaks Multiple-day trips allowed
Scheduling Requirements	Assignment of customers to day of the week Time-windows for pickup/delivery (soft, hard) Open and close times Load/unload (dwell) times
Data Requirements	Geographic database, road networks Customer addresses and locations Travel times Vehicle location information Customer credit and billing information

3) Solution Approach

a. Statics Adoption Approach

First category is fast local operations [7], which mainly use an insertion technique, fall into the first category. This method is easy to implement and delivers a fast. This 'fast local' operation is appropriate for a dynamic environment, where computation time is an important factor. These approaches lose the opportunity of re-optimizing existing routes by swapping and/or reordering to improve the solution.

The second category is a sophisticated static problem-solving procedure, which involves a re-optimization of existing routes. This approach consists of solving a mathematical programming formulation. However, applicability of that approach is at present limited to relatively small problems, because of its computational intensiveness.

b. Metaheuristics Approach

Another solution approach is to use meta-heuristics based on a searching algorithm. The effectiveness of these methods depends on their ability to adapt to a particular realization, to avoid entrapment at a local solution, and to exploit the basic structure of the problem. The drawback of these approaches is that the solution quality is unstable. In other words, the

solution quality depends on the parameter settings. As a result, new parameter settings might be required depending on the problem realization.

Metaheuristics [8] are different in the sense that some of them are population based (EC, ACO), and others are trajectory methods (SA, TS, ILS, VNS, GRASP), and although they are based on different philosophies, the mechanisms to efficiently explore a search space are all based on intensification and diversification. Nevertheless, it is possible to identify "subtasks", subtasks" in the search process where some metaheuristics perform better than others. This has to be examined more closely in the future in order to be able to produce hybrid metaheuristics performing considerably better than their "pure" parents. High quality solutions for Vehicle Routing Problem are obtained with Genetic Algorithms [9]. In fact we can find this phenomenon in many facets of life, not just in the world of algorithms. Mixing and hybridizing is often better than purity.

C. Decision Support System Framework

This research will consider four dimensional frameworks of DSS. First dimension is model-driven DSS framework. These frameworks focus on optimization and will use simulation to test the model as a first step [10]. Model-driven DSS use data and parameters provided by users to assist decision makers in analysing a situation; they are not necessarily data-intensive.

Secondary dimension of DSS, this research will intend to intra-organizational decision support. Third dimension is purpose of DSS. This research will provide general purposes of DSS. This system will help support broad tasks and decision analysis. Fourth dimension that have to consider is enabling technology for implementation, as mention on section 2, this system will consider hardware and software environment such as communication device and software architecture [11].

III. DISCUSSION AND FUTURE WORK

Implementation of Fleet Management Technology must well consider regarding a lot of cost. Small and Medium Enterprise (SME) look at this implementation become serious constraint. SME need alternative way to implement this in cheaper cost but near effectively.

Main problem which stated above is how to deal with unforeseen situation and impact to delivery execution. This situation must handle effectively and efficient manner. Achieving delivery objective and solving this problem need a model to be formulated. Model for Real-time/Dynamic environment need an agent to resolve rerouting or assign new vehicle to replace the task. Penalty must be calculated as influence from solution that had implemented. In this case there's multi objective to achieve in the Model which must be considered well, there are to achieve minimum cost and

penalty and maximum percentage of delivery execution success.

The model for this research will be included in Decision Support Module. The other modules that will be developed are User Interface Module, Data Management Module and User Control Module. The future works that must follow are: (i) Design and Develop Model and do simulation, (ii) Validate model against real case study, (iii) Design and Develop DSS Framework.

IV. CONCLUSION

Distribution plans execution often faces to unforeseen adverse condition that will become unexpected costs. Existing real-time fleet management system can fulfil as subset of the requirement expressed by logistics and distributions organizations. Existing real-time must have ability to reroute vehicle intelligently and deal with vehicle breakdown.

Dynamic Fleet Management model will be considered as appropriate one to develop. This model will be simulated first and validated by real case study. Finally the model will be integrated to decision support system as Decision Support Module.

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