REAL-TIME LOGISTIC RECOVERY UNDER SCHEDULE DISRUPTIONS

Pitu B. Mirchandani
Department of Systems & Industrial Engineering
Department of Electrical & Computer Engineering
Applied Mathematics Program
The ATLAS Center,
The University of Arizona,
Tucson, AZ 85721, USA
pitubm@aol.com

ABSTRACT

Logistic and transportation system might be susceptible to unexpected costs and delays due to unforeseen events, such as vehicle breakdown, traffic delay/accident, road works and medical emergency. In such situations, a priori algorithmic solution may deteriorate and the fleet plan needs to be adjusted in real-time as a function of the dynamic system state. The real-time logistic recovery can be approached as a dynamic version of the static logistic problem (e.g, vehicle scheduling/routing) where assignments are generated dynamically. Logistic recovery problem arises in a wide array of practical applications. Instances include school bus routing, goods delivery and pickup, operational planning of public transportation systems, industrial/hospital refuse collection, mail delivery, and telecommunication systems.

When an unexpected event occurs, some existing vehicles need to be rescheduled and some extra vehicles from the depot may be allocated to conduct the recovery. Vehicle breakdown might be the worst case among unexpected events, since it demands picking up the passengers/cargo from the breakdown vehicle. The selection of the backup vehicle involves several factors such as the time when the trip was disrupted, the position of the remaining vehicles, the available capacity of the potential backup vehicles, and the itinerary compatibility among trips. Additional issues may be required in the different problems.

The purpose of static logistic problem is usually to minimize the total fixed vehicle and operating costs. Nevertheless, the delay cost plays an important role in real-time logistic recovery problem, since the significant delay deteriorates the quality of service. If the purpose of a rescheduling approach is only to minimize the fixed vehicle, operating and delay costs, the new schedule might be considerably different from the original schedule.

These changes can put the crews into a difficult situation, since it is essential that all teams know the itinerary of each new trip. Although it is

almost impossible to obtain a solution without effecting the initial schedule, it is possible, in order to decrease the number of possible changes in the initial schedule, to introduce penalties in the cost of some arcs of the vehicle scheduling networks.

Therefore, a general logistic recovery problem can be defined as follows. Given a depot or several depots and a series of trips (or customers), given the travel times between all pairs of locations, and given an unexpected event, find a feasible reschedule with minimum-costs, including fixed vehicle, operating, delay and rescheduling costs, in which (1) all vehicles, including existing vehicles and new vehicles from the depots, perform a feasible sequence of trips, and (2) all passengers or cargo affected by the unexpected event are served.

Furthermore, in order that crew can be reassigned on a new schedule, the computation needs to be carried out as fast as possible. Considering the different problems, some additional constraints need to be included. For example, in vehicle routing problem with hard time window, it should be guaranteed that service time has to be within the time window.

The following is the outline of the presentation:
• A framework for decision/control will be presented and some typical "real-time" logistics and transportation scenarios will be illustrated
• The notions of "on-line" and "real-time" algorithms and "routine" and "infrequent" disruptions will be introduced and discussed.
• Models and solutions for "Real-time Vehicle Rescheduling" and "Real-time Vehicle Re-Routing" will be formulated and studied.

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Key Words: *Real-Time Logistic, Vehicle Rescheduling, Vehicle Re-Routing.*