Congestion Reduction through Efficient Container Movement under Stochastic Demand

PI: Maged Dessouky
Daniel J. Epstein Department of Industrial and Systems Engineering
University of Southern California, Los Angeles, CA 90089-0193
Email: maged@usc.edu

Project Objective

The rapid growth in international business leads to a massive upsurge in demand for containers and trucks to carry the commodities, which raises traffic and environmental problems near the port area. These problems are usually studied as “Empty container reuse problem”. Most of the research has been conducted on moving containers under known deterministic demand. However, in reality the demand can be uncertain and there is a need to develop models to account for demand uncertainty. In this study, an optimization-based vehicle scheduling framework is proposed to solve the empty container reuse model considering future stochastic demand.

Problem Statement

There is a significant increase in international trade between the U.S. and other countries all over the world in the last decades. The rapid growth in the business leads to a massive upsurge in demand for containers and trucks to carry the commodities, which raises traffic and environmental problems near the port area. Additionally, the imbalanced containerized trade between import and export commodities and the business agreements of container leasing results in more than 20% of the container movements involving empty containers. It is essential to wisely manage the container movements so that the congestion at peak hours can be relieved, and the emission can be reduced. Most of the current research focuses on the deterministic demand model, but, in reality, the container movements are not only to fulfill today’s demand but also to prepare for the next day’s delivery. The main challenge of preparing for the next day delivery is that tomorrow’s demand is stochastic. However, since the shipping schedule at the port is predictable with certain probabilities and historical data, the demand at the nearby warehouses could be estimated based on the port state. Therefore, considering the future demand into the container movement plan is promising. In conclusion, there is a need to develop an overall procedure to model and provide strategies that can satisfy both today’s demand and future stochastic demand with a smaller fleet size and fewer truck miles.

Research Methodology

A framework (see Figure 1) is proposed to solve an optimization-based vehicle scheduling model that satisfies both today's and tomorrow's stochastic demand. By solving container assignment problem iteratively using a two-day time horizon, the vehicle routing solution can be constructed for a consecutive period. A stochastic demand model is formulated to incorporate both today and tomorrow's demand. The model is solved daily with two-day demand. Only the first day's vehicle routing would be executed. In this case, the final state of the first day will be the initial state of the second day. In the stochastic model, multi-trailer trucks are considered as the carrier of the containers, while considering container reuse strategies. The stochastic model provides a routing plan that strictly satisfies today's demand with a certain penalty for not fulfilling tomorrow's demand. The aim of the approach is to reduce the total number of trucks in the network and reduce the total truck miles in a long run.

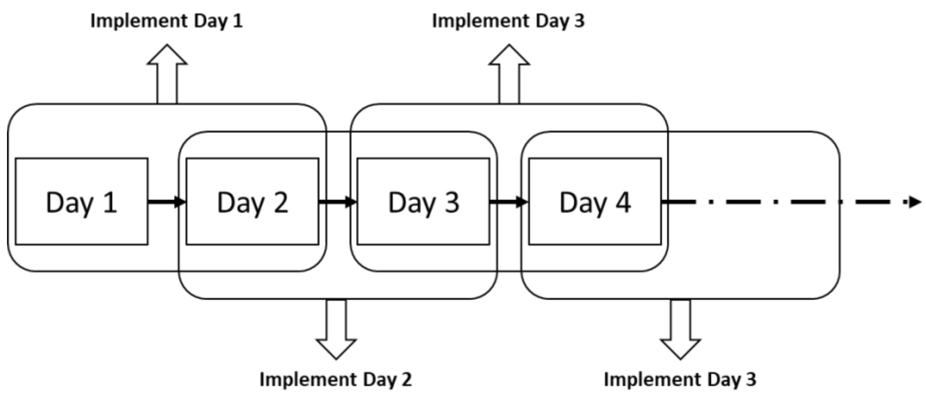

Figure 1. Framework for solving the stochastic demand container assignment problem

Results

The proposed stochastic container assignment and vehicle routing model was tested using container demand data from the Ports of Los Angeles and Long Beach as well as randomly generated data sets. In the experiment, there are three main events at the port, which were represented by a set of transitional probabilities and the demand distribution. All the experiments were on a ten-day scale. For the facility location, two groups of experiments were performed under randomized locations and the actual locations in the Port of Long Beach. In each group, the result of solving the model with knowing all the future information was considered as a baseline. By comparing the results with those results from the stochastic model and the model without future information, it turns out that the stochastic model performs 4-6% better than the one without considering future demand in both groups. This study shows the advantage of incorporating future information into the current container management plan.