# Congestion Reduction through Efficient Empty Container Movement

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## Project Objective

There is a significant amount of container truck congestion in and around the ports area, and it will most likely worsen as container demand continues to increase. Historically, there has been a lot of research done on how to move loaded containers effectively. However, to improve efficiency, the flow of empty containers must be incorporated into the study. Moreover, the use of double container trucks is becoming more common throughout the world and these trucks offer the possibility of greatly reducing total truck trips. The objective of this project is to improve efficiency and reduce congestion by making a container movement schedule that incorporates both loaded and empty containers. The plan can be made using both double and single container trucks, or restricted only to single containers if the road infrastructure cannot accommodate double container trucks.

## Problem Statement

There is a significant amount of investigation regarding how to efficiently distribute loaded containers from the ports to the consignees. However, to fully maximize the process and become more environmental friendly, one should also study how to allocate the empty containers created by these consignees. This is an essential part in the study of container movement since it balances out the load flow at each location. Currently, most container movement at the Ports of Los Angeles and Long Beach follow a simple movement, going from the port to importers and then back to the port as an empty container. Subsequently, some of these empty containers go from the port to exporters and then return as loaded containers to the port. This creates a lot of unnecessary traffic. For example, in 2015 the Ports of Los Angeles and Long Beach had 15.3 million Twenty-foot Equivalent Units (TEU). About 30% of this (or 4.3 million TEUs) were empty containers. This is a significant amount of unnecessary empty container movement. There is rarely any container movement from the importers to exporters. The reason for this is that importers want to get rid of their empty containers as fast as possible, while exporters want their empty containers just in time. Connecting one importer and one exporter so that they may exchange empty containers is a complex optimization problem that requires state-of-the art algorithms to solve. The problem to optimize is then to determine the container assignment so that containers move at the right time and place, and to route the trucks to fulfill these container movements.

## Research Methodology

We propose a mathematical model for the empty container problem using double and single container trucks. The model discretizes time and ensures that demand is met. We separated the problem into two main components, the assignment of container movement and the assignment of truck routes. We formulated the assignment of container movements as an Integer Programming (IP) model. The container movement from one location to another are the variables and the objective is to minimize the transportation costs while meeting all the demand for both loaded and empty containers. In order to solve the model, we first solve the Linear Program Relaxation. We then round down the fractional variables and hold these variables as fixed which results into a much smaller IP model which can be easily solved. This model determines the movement of containers. We then use these movement of containers to determine the truck routes. We propose an algorithm that minimizes idle time between jobs to obtain an initial feasible solution and then the initial solution is improved using an Adaptive Large Neighborhood Search Heuristic to obtain the final routes that minimize the truck miles.

## Results

We test the proposed model using container demand data from the Ports of Los Angeles and Long Beach as well as randomly generated data sets. Our tests focus on intermodal stations where 40-foot containers and 52-foot containers are switched. These locations are located within 20 miles from the port. We test the model using the current policy of no container reuse (see Figure 1), a container reuse policy using only single container trucks, and a container reuse policy using both single and double container trucks (see Figure 2). These experiments show that there is an improvement over the current policy in using both single and double container reuse policies (see Figure 3). The container reuse policy using only single containers has a 12% reduction in truck miles compared to the current policy and there is a 55% reduction when using both single and double container trucks (see Figure 3). The reason for this reduction is that by reusing empty containers the system can become more efficient and not waste truck trips on empty containers.

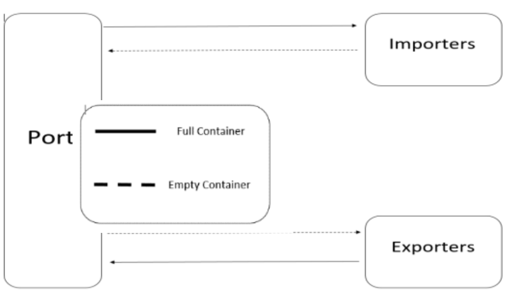


**Figure 1. Current Container Flow**

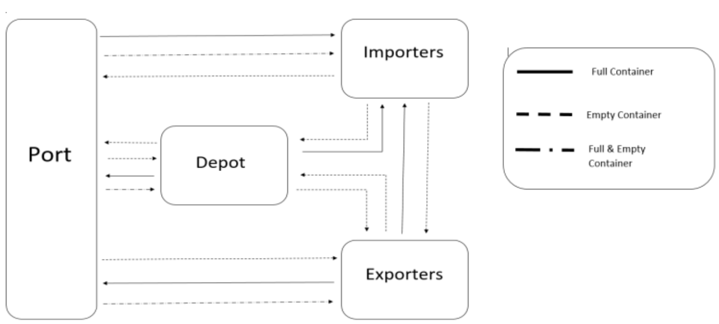


**Figure 2. Proposed Double Container Flow**


**Figure 3. Total Truck Miles for Different Policies**