

The container was invented in the 1950s and it is widely assumed that the containerization is one of the main factors of the growth of world trade. The number of containers transported each year is still growing and so is the size of container ships. The increasing size of container ships puts pressure on the deep sea terminals which should provide efficient loading and unloading of a sea vessel. However, also the transportation to the hinterland needs attention. A sea vessel can carry thousands of containers and if all containers are picked up as fast as possible by truck, it would mean a queue of thousands trucks waiting at the gates of the terminal. Besides, freight rates are falling, which was clearly been illustrated with the bankruptcy of the shipping company Hanjin in October 2016. Therefore, it is important to focus on an efficient transportation of containers to the hinterland.

In this project, we consider a logistic provider that is responsible for the transportation of containers from multiple deep sea terminals in Rotterdam to one inland terminal. The decision for the logistic provider is, for each container, on which day it is transported and by which mode of transportation (truck or barge). It is preferred to transport a container by barge, because it is the cheapest way of transportation. However, sometimes there might be a reason why containers are shipped by truck. For example, a truck is much faster than a barge, which might be useful if the time is limited. Moreover, the capacity of a barge is limited, so sometimes not all containers fit on a barge.

You are expected to build a decision support tool that helps the logistic provider in this decision. The goal of the tool should be to decide on the mode and day of transportation for all containers in order to get the best possible planning. The planning you should make is on a daily basis. An external shipping company provides the logistic provider with a barge schedule, which tells you which ship is on which day in Rotterdam. The logistic provider let the shipping company know which container they want to be shipped on which day. The route the barge will sail via all deep sea terminals is decided by the shipping company and outside the scope of this project.

All containers arrive by a deep sea vessel at a terminal in Rotterdam. As unloading a sea vessel usually takes 24 hours, we can assume that the earliest transportation date of a container is a day after the arrival of the sea vessel. The **barge** sails overnight from Rotterdam to the inland terminal, which takes about 12 hours, so we may assume that the container arrives at the inland terminal the day after it is loaded in Rotterdam. A **truck** can drive in a couple of hours from Rotterdam to the inland terminal, so it may be assumed that the container arrives at the inland terminal on the same day as it leaves Rotterdam.

Each customer has a latest delivery date, the so-called **call date** and the container must be at the customer by then. Since all customers are located in the neighborhood of the inland terminal, it is sufficient to assume that a container is at the inland terminal at the call date. The final shipment of the container to the customer is not of interest in this project.

There are **two types of costs**: **transportation** costs and **demurrage** costs. The container terminal made an agreement with the external shipping company such that for each container both the costs of shipping by barge and truck are **fixed** and known for each container. The demurrage costs are associated with the time the container is at the deep sea terminal. The moment a sea vessel arrives at the deep sea terminal, the demurrage period for the containers on that vessel starts. The demurrage period for a container ends when it leaves the deep sea terminal. The demurrage period of a container is calculated in days, so it does not matter if a sea vessel arrives at 1 AM or 11 PM, in both cases the day the sea vessel arrives at the terminal is the first day of the demurrage period. The same holds for the end of the demurrage period. Please note that both the arrival day as the departure day of a container at a deep sea terminal are part of the demurrage period. So when a container arrived at the deep sea terminal yesterday and will leave tomorrow, the demurrage period is 3 days. Each container

has a demurrage free period for which it does not have to pay any demurrage costs. For each day the container is at the deep sea terminal after the demurrage free period, a certain amount of demurrage costs has to be paid.

The size of container is measured in Twenty foot Equivalent Unit (TEU). The containers under consideration are 1, 2, or 3 TEU. Besides a size in TEU, each container also has a weight in kilograms. Each barge has a maximum capacity in TEU and a maximum capacity in kilograms. We assume that a barge is only one day in the port of Rotterdam. That means that each container that is loaded on a barge will be one day later at the inland terminal.

It can be assumed that there is an unlimited amount of trucks available each day. Moreover, the **container transported on a truck can be of any size or weight**. The only limitation in transporting a container by truck is that **only one container fits on a truck**. So a truck can ship one container of 2 TEU, but not two containers of 1 TEU.

Mooring a barge is a time-consuming operation and there is also a possibility on congestion at a terminal which will result in a delay of the barge. If the total delay of a barge on one day is too large, the barge might not be able to reach the inland terminal in time. So the number of terminals visit by barge should not be too large. However, a lower number of barge terminal visits may result in higher demurrage costs and more transport using trucks, so also higher transportation costs. The planning should make a **good trade-off between the number of visited terminals by barge and the total costs**. There are many possible ways to make the trade-off, it is up to you to decide which choice(s) you make in this trade-off.

The logistic provider requires **two different types of planning**. The first type of planning may start at midnight and have 6-8 hours to provide a planning. However, during the day new orders arrive and orders are changed or canceled. So there is also need for a method that can provide a planning in a few seconds.

The planner should be able to manually adjust the planning that is given by the decision support tool. He may would like to force a container to use a certain mode and/or day of transportation. Besides, he must be able to decide whether a terminal is visited by barge on a specific day. If these manually imposed conditions result in an infeasible schedule, for example when the number of TEU on a barge exceeds its capacity, the decision support tool should report that. If the planning is still feasible, the tool should provide a planning that satisfies the condition and it should also report the cost of the extra condition, i.e., the difference in objective function between the old and new scenario.

All in all, the goal is to build a decision tool that provide a **feasible planning for minimal costs and terminal visits**. The tool should have a 'slow' and a 'fast' method to calculate the planning and a planner should have the possibility to adjust the planning manually.

You have the following information at your disposal:

- Container input (file: Input containers.xlsx)
 - Arrival day of sea vessel
 - Call date of customer
 - Size in TEU
 - Weight in kilograms
 - Deep sea terminal where container is located
 - Demurrage free days
- Barge input(file: Input barge.xlsx):

- Each day the barge is in Rotterdam
 - Maximum capacity in TEU
 - Maximum capacity in kilograms
- Cost input:
 - Cost of transporting a container by barge
 - €40 per TEU
 - Cost of transporting a container by truck:
 - €225 for every type of container
 - Demurrage cost for each day container is at the deep sea terminal after the demurrage free period:
 - €50 for 1 TEU containers
 - €70 for 2 and 3 TEU containers

The first day of transportation is tomorrow and all containers should have been loaded in Rotterdam 10 days after today. Today is denoted in the dataset as day 0, so tomorrow is day 1 and the last day of transportation is day 10.