

Team Working Activity on the Train Load Planning Problem

Let us consider a railway yard in an intermodal terminal in which there is one storage area and trains to be loaded and unloaded by one crane, whereas reach stackers are used to move containers between the storage area and the tracks.

There are 20 containers in the storage area, denoted as $c1, c2, \dots, c20$, that are stored in 5 stacks of 4 tiers. The first 3 stacks (containers $c1$ to $c12$) are dedicated to 20' containers, while the last 2 stacks (containers $c13$ to $c20$) are for 40' containers. In the figure the position of containers in the storage area is depicted. Moreover, for each container the weight in tons is reported, as well as the priority, with 'L' indicating low priority, 'M' indicating medium priority and 'H' high priority.

c4 - 18t - H	c8 - 18t - L	c12 - 19t - L	c16 - 25t - L	c20 - 27t - L
c3 - 17t - M	c7 - 17t - L	c11 - 18t - H	c15 - 27t - H	c19 - 24t - L
c2 - 19t - H	c6 - 16t - M	c10 - 19t - M	c14 - 24t - M	c18 - 24t - H
c1 - 15t - M	c5 - 15t - H	c9 - 16t - M	c13 - 22t - L	c17 - 28t - L

Figura 1: Containers in the storage area

The train to be loaded is composed of 7 wagons. Each of the first 4 wagons has a capacity of 3 TEUs and a maximum acceptable weight of 48 t, while the last 3 wagons have a capacity of 2 TEUs and a maximum acceptable weight of 33 t. Moreover, the maximum weight for the entire train is 300 t.

The terminal manager wants to decide the optimal assignment of containers to wagons considering that the train is loaded sequentially by the crane, the capacity constraints must be addressed and both the rehandling cost and the commercial value of the containers that are not loaded must be minimized. To define the optimization problem, consider a rehandling cost for each operation equal to 10€ and a commercial value of containers defined according to their priority as follows: for 20' containers, low priority corresponds to a commercial value of 20€, medium priority to a commercial value of 30€ and high priority to a commercial value of 40€. These commercial values are doubled for 40' containers to account for the fact that they have a double occupation in the train.

1. Write the mathematical programming formulation for this model (with data with their values, decision variables, objective function and constraints).
2. Implement this model and report the following information regarding the optimal solution:
 - which containers are loaded in each wagon
 - list of containers remaining in the storage area
 - number of TEUs loaded
 - total priority (commercial value) of containers loaded
 - percentage use of the train TEU capacity
 - which containers are rehandled while loading the wagons
 - number of rehandling operations
 - cost for rehandling operations