CHAIR OF PRODUCTION MANAGEMENT
Prof. Dr. Raik Stolletz
http://stolletz.bwl.uni-mannheim.de

UNIVERSITY OF MANNHEIM

OPM 662 – Business Analytics : Modeling and Optimization (FSS 2022)

Assignment 3: Jetty Scheduling

Due date: May 2nd 2022, 20:22 CET

Problem Description

Since you are a renowned expert in operations scheduling, Company Beta contacted you to help them optimizing the shipping operations at their local industrial harbor.

Company Beta owns several ships $(s = 1, ..., S)$ of different categories $(c = 1, ..., C)$. Every ship arrives with a full tank that must be emptied at a so-called jetty. A jetty is a canal with four stations $(p = 1, ..., 4)$ for unloading, aligned in one row.

Figure 1: A cargo ship entering at the jetty

Before a ship enters the jetty it has to pass through a waiting position. Because of the slow speed of the ships, it is possible to forecast their arrival time at the waiting position and the earliest time period a_s to enter the jetty.

The ships enter the jetty one by one and are unloaded at exactly one of the four stations. The time $u_{c,p}$ required for unloading differs for every ship category and every station. Splitting the unloading process to multiple stations is forbidden.

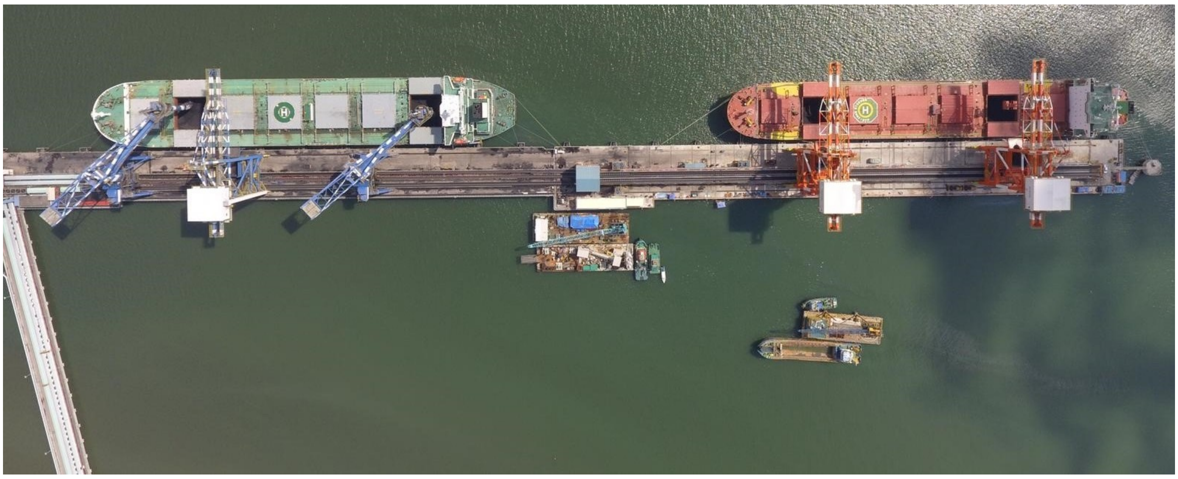

Figure 2: Ships at the jetty

While passing through the jetty, ships can only go forward and cannot overtake other ships. Hence, if a ship has finished unloading, but the ship at the subsequent station has not, the ship at the previous station is blocked and has to wait.

In contrast to the jetty, a ship can overtake other ships at the waiting position, *i.e.,* their order is not pre-determined. After a ship leaves the jetty, it reaches the open sea.

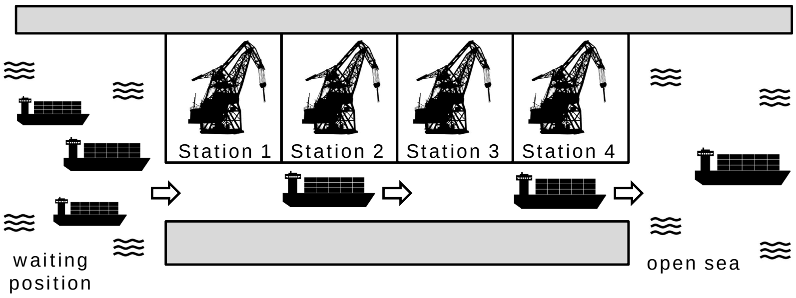

Figure 3: Schematic illustration of a jetty with 4 stations

Company Beta wants to have a schedule for the jetty, *i.e.,* they need to know, in which order the ships should pass the jetty, and at what time and station they should be unloaded. Time is given in 15-minute periods $(t = 1, ..., T)$. It takes 1 period for a ship to pass through each station without unloading.

As the ships are only profitable if they are in use, they need to pass the jetty as fast as possible, in order to be ready for their next job. Therefore the goal is to minimize the total sum of periods that all ships are at the waiting position or at the jetty, until they enter the open sea again.

Table 1 shows the unloading times $u_{c,p}$ for the different ship categories and stations. Table 2 shows a small problem instance with 4 ships and their respective ship categories and arrival times.

An optimal solution to the example in Table 2 is given in Table 3. The objective value is **25** periods, until the ships have reached the open sea again: Moers (5 periods) + Exxon (7 periods) + Tornado (5 periods) + Nina (8 periods).

	time for unloading $u_{c,p}$ (in periods)			
ship cat. c	station $p = 1$	station $p = 2$	station $p = 3$	station $p = 4$
$c = 1$	3	5	7	incompatible
$c = 2$	incompatible	6	7	9
$c = 3$	4	3	7	2
$c = 4$	5	7	incompatible	1
$c = 5$	2	5	9	7

Table 1: Unloading times for the different ship categories

ship s	name	category c	earliest period a_s
1	Exxon	1	1
2	Nina	5	3
3	Moers	3	1
4	Tornado	4	4

Table 2: Small problem instance with 4 ships

ship s	name	order	unload at station
1	Exxon	2.	1
2	Nina	4.	1
3	Moers	1.	4
4	Tornado	3.	4

station | time	1	2	3	4	5	6	7	8	9	10
$p = 1$	Moers	**Exxon**	**Exxon**	**Exxon**	Tornado	**Nina**	**Nina**	-	-	-
$p = 2$	-	Moers	-	-	Exxon	Tornado	-	Nina	-	-
$p = 3$	-	-	Moers	-	-	Exxon	Tornado	-	Nina	-
$p = 4$	-	-	-	**Moers**	**Moers**	-	Exxon	**Tornado**	-	Nina

Table 3: An optimal solution to the example in Table 2

Instructions

1. Formulate and solve the decision problem stated above. In particular:
   a. Structure and describe the decision problem in terms of input, decisions, objective and constraints.
   b. Define an optimization model in algebraic notation.
   c. Implement the model in Python.
   d. Find the optimal solution of the problem instances **1** and **2** provided in the attached Excel file. Import the problem data directly from Excel and export your results to Excel as well. **(20 P.)**
2. Develop a heuristic solution approach (aggregation or decomposition) for the jetty scheduling problem. Description the basic idea of your approach in the report and implement it in Python. Evaluate the performance of your approach using the large problem instance **3**. **(10 P.)**

3. Prepare a 15-minute presentation of your algebraic model, your heuristic approach and your numerical results. **(5 P.)**

Please send your results (report (max 10 pages), presentation, complete Python implementation as zipped files) to **opm662@bwl.uni-mannheim.de**.

This case is based on a real-life optimization problem and was provided by OM Partners (http://www.ompartners.com).