We are investigating a maritime container terminal in which containers arrive and depart via ships, trucks, and trains. The terminal comprises three subterminals, each dedicated to a specific transportation mode (ship, truck, train), along with a vast storage yard. Containers are transported by various types of handling machines, each with its own maximum handling capacity, representing the maximum number of containers the machine can manage within a given period of time. The goal is to identify optimal percentages of the maximum handling capacities for the machines to minimize the duration of container remaining in the terminal.

The flowchart illustrates the overall layout of a maritime terminal, showcasing its various components and handling machines. The black, purple and green arrows indicate the directions of container movement. As the terminal is maritime, containers arriving by trucks or trains must depart via ships, whereas the departure does not matter if containers arrive via ship. Containers located at one specific part of the terminal (station) form a “Queue”; the containers in movement between the yard and the subterminals form the so called “Handshake Queues”.

**Approach - Balance Equations**

By using a discrete time grid, the movement and conservation of containers within the terminal are articulated through difference equations known as “Balance Equations”. These equations establish a relationship between the queue lengths at two consecutive time points, the present handling capacities of the handling machines, and the containers arriving and departing the terminal.

**Optimization Problem**

Instead of directly minimizing the process time, we optimize the handling process to ensure swift transfer of containers from one machine to the next one using a targeted objective function, efficiently minimizing the time by preventing container delays on paths. To this end, the summations $\sum_{k}$ and $\sum_{x}$ in the objective function sum up the squared differences between the current handling capacities of two consecutive handling machines at point of time $t$, multiplied by suitably chosen weighting parameters, for the ship- truck and train-subterminals each. For example, the squared difference of the handling capacities of the quay cranes unloading and the yard trucks to the yard is given by $(\delta_{0} + \delta_{3})^2$.

**Results**

The optimization problem was solved using the optimization software “WORHP”, for the visualization of the numerical result the programming language Python was used.

**Conclusion/Outlook**

In summary, the examination is focused on a maritime terminal where we enhance the efficiency of container flow under normal circumstances - ensuring a balance between incoming and outgoing containers without any irregularities. An extension of the model could involve incorporating considerations for unusual phenomena and determining an optimal container flow in such scenarios. One the one hand, these phenomena may encompass natural occurrences such as weather conditions, for instance strong winds. On the other hand, they also encompass human made disruptions, such as a lack of labor, failure of handling machines or accidents, for instance the Ever Given accident in the Suez Canal in March 2021.

**References**


