IEOR 4405
Production Scheduling

Class Project: Truck Assignment Problem in Ports

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Contents

Introduction

- We are trying to find an **optimal schedule for trucks** to pick up containers from ships at a port.

- **Is it better to have mini fleets of trucks assigned to a specific crane or a larger fleet with trucks dynamically assigned to any crane that needs a truck?**

Introduction

DP WORLD
Chile

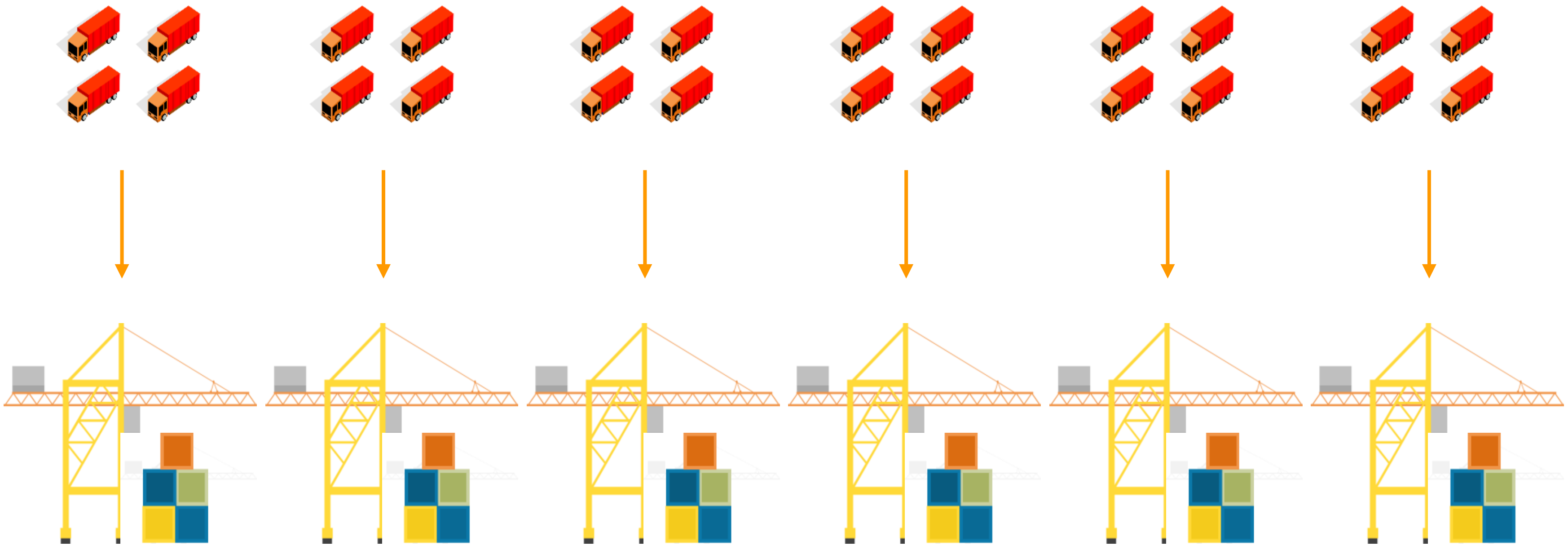
- We decided to model the truck operations at DP World Lirquen (Chile)
- We met with the port manager & engineers to learn about the system and details of port operations
- Our objective: **help port staff understand how to optimize the trucks for any individual ship with a specific number of containers**

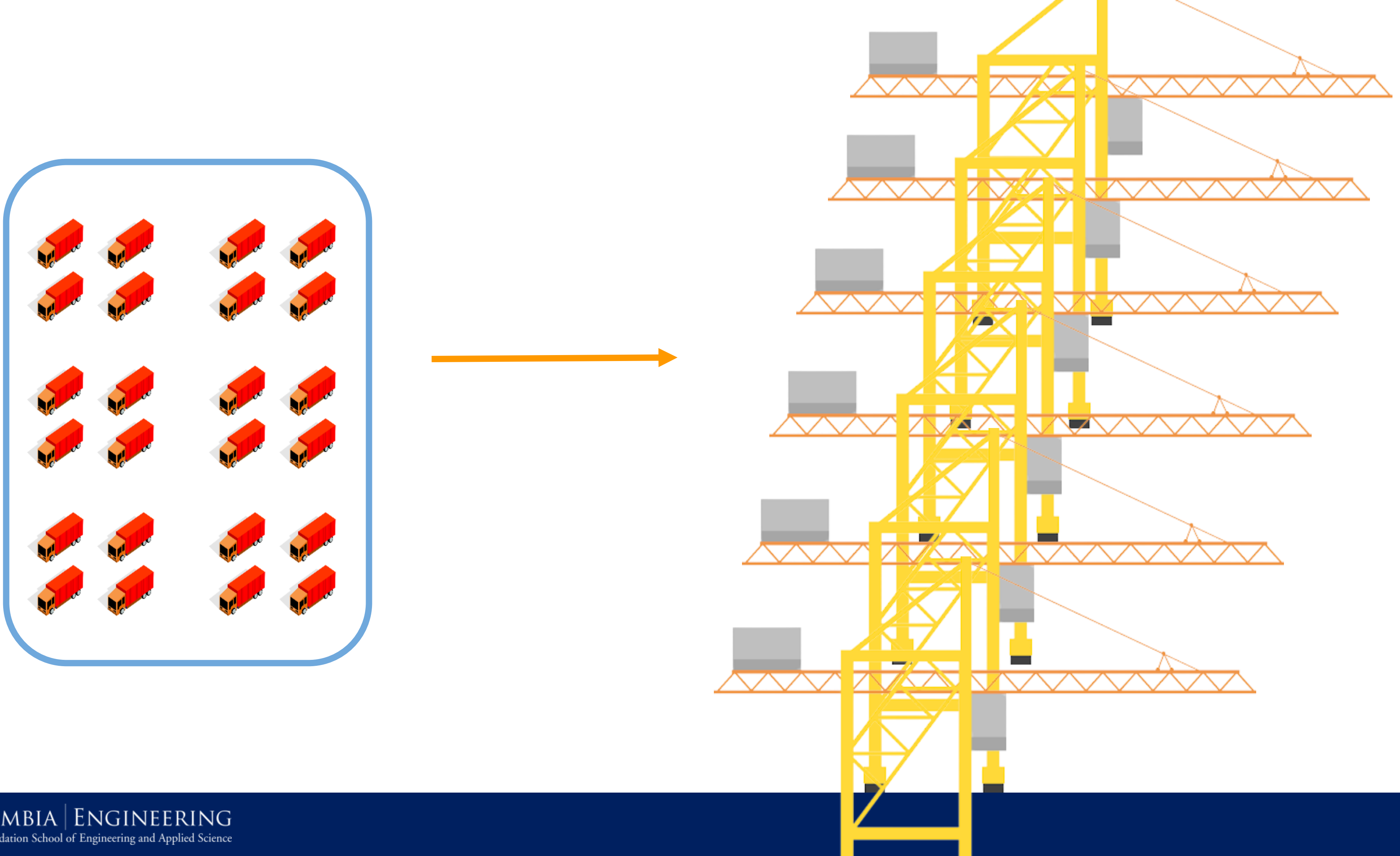
Introduction

- Operation: A ship reaches the port and cranes unload containers onto trucks. A truck must be present for the crane to release the container to the truck.
- Based on the assignment of the trucks, the problem can be split into 2 subproblems.
    - 1: Trucks as smaller, fixed fleets.
    - 2: Trucks as part of one larger fleet.

Problem 1 - Current Port Model

Trucks as smaller, fixed fleets





General Parameters

- **For cranes:** Cranes are paralleled. A crane can drop off one container every 3.75 minutes (as long as the one before is already picked up)

- **For containers:** Each crane has a workload of 275 containers per ship.

- **For trucks:**
  - There are at most 24 trucks in total
  - The travel time for a truck is 12 minutes (round trip)

- We are **minimizing the maximum makespan**, i.e., the maximum of the subproblems

The Base Problems (Deterministic)

- It is a **p|r_j|c_max** problem

- Simplified assumption: **no double cycling** (a truck never unloads and reloads during the same trip)

- Model the subproblems by adjusting the number of trucks in each fleet (p)

- The cranes have a 100% utilization after p=4. And the trucks have some idle time. However, the containers have no wait time.

The Advanced Problems (Stochastic)

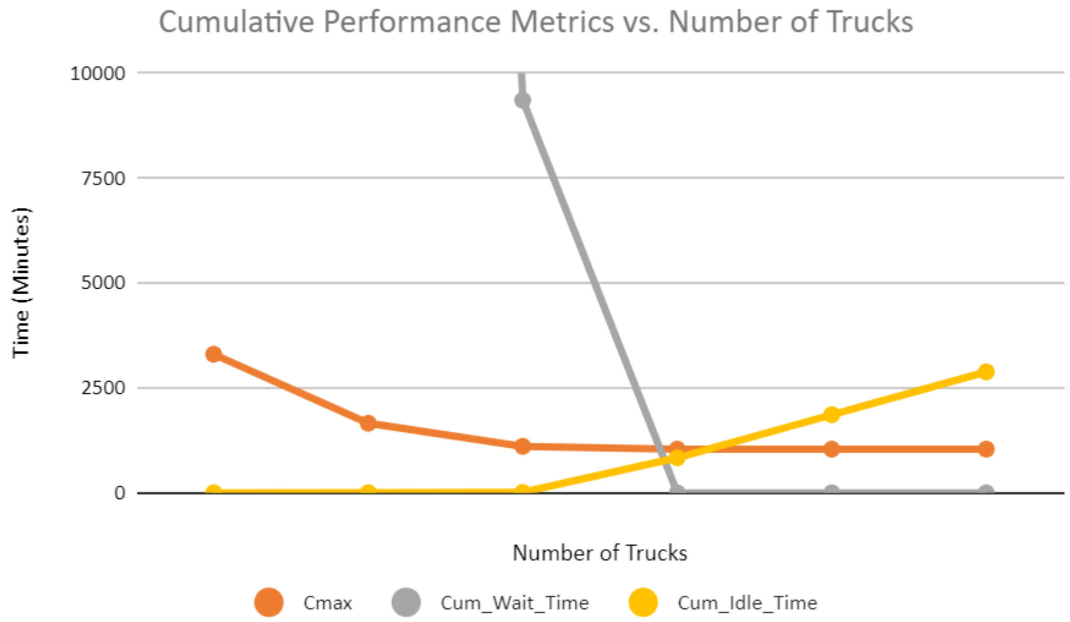
- To better represent the real world, many of our discrete assumptions should be made into **stochastic assumptions.**
- The crane rate is assumed to be gaussian with **mean 3.75 and standard deviation 0.3**
- The truck processing times are assumed to be gaussian with **mean 12 and standard deviation 1**
- To compare makespans of both problems we proceed to run the output 1000 times and average the results.

Methods

- We used excel to create schedules based on the assumptions mentioned before.
- We used simpy to also create schedules, and confirm that we were obtaining correct results by comparing simpy and excel schedules
- Simpy allowed us to run the simulation many times with different parameters and find edge cases.

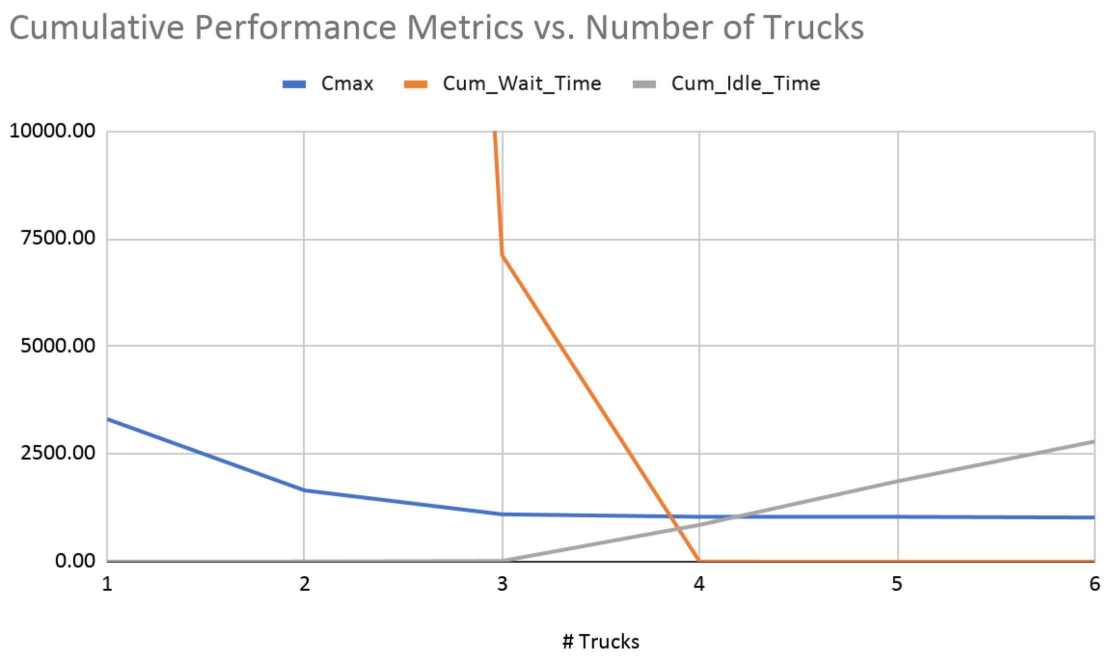
Results & Discussion

Problems 1 & 2: Deterministic Model:



Results & Discussion

Problem 1: Stochastic Model:



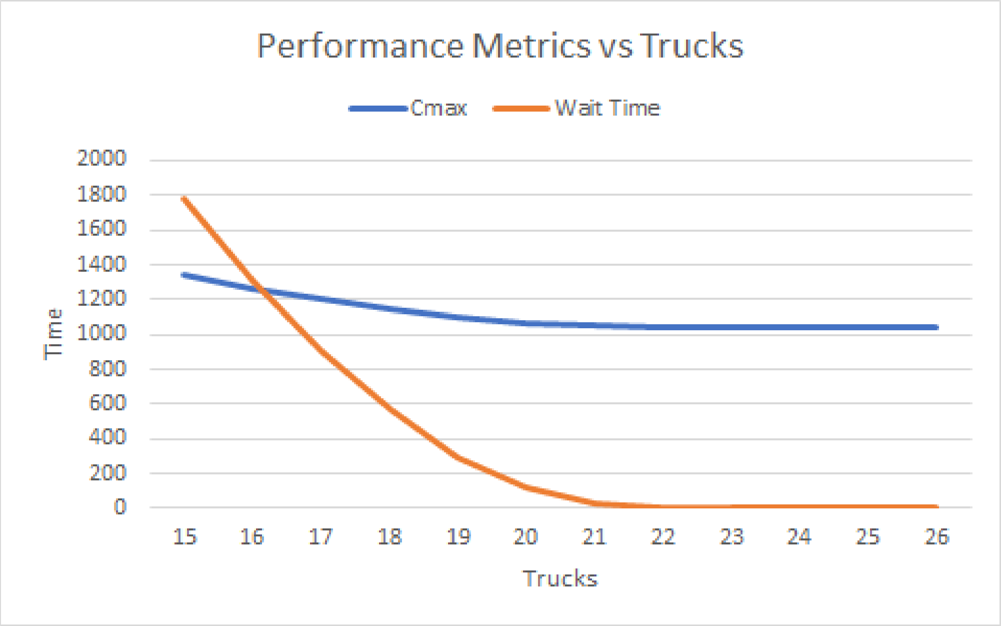
Results & Discussion

Problem 2: Stochastic Model:

- 24 trucks, 6 cranes averages to 4 trucks per crane
- Similar optimal makespan performance.
- Average makespan is converges to around 1040
- Decreasing trucks from current 24 to 22 also gives similar optimal

Results & Discussion

Problem 2: Stochastic Model:



Conclusions

- Both the deterministic and stochastic version of the problems yield similar decisions regarding the assignation of trucks in the port.

- In problem 1 we can visualize how the increase if trucks that take part in the "team" decreases the maximum makespan of the particular crane. The makespan can only go as low as the rate of the crane allows it.

- Since the release dates of the containers are subject to the one before being picked up, the optimal schedule is assigning trucks to containers by their release dates.

Conclusions

- We can also observe how the problem 1 with 4 trucks and problem 2 with 24 trucks yield a very similar makespan.

- Problem 2 allows us to use fewer trucks (>24) maintaining a similar makespan, opening a future analysis on cost reduction.

- Real time truck assignment would require a dispatcher (increased labor costs) or new technologies to dynamically assign trucks (increased equipment cost). These costs were not modeled in our formulation

- Tradeoffs between idle time of wait time of cranes/containers, vs. wait time of trucks should be considered. These idle/wait times have different labor costs associated with them

Next Steps

- Continue modeling randomness, introduce more complexity into the models
  - complexity includes double-cycling, different cranes having different rate distributions
- Get more data and refine the data
  - i.e. double-check that the processing times are modeled correctly with an average of 12 minutes
  - introduce variable workloads per crane
    - this depends on the specific ship, and the orientation of containers on the ship
- Introduce cost modeling
  - Assign costs to idle time, wait time, etc. based on the port's labor and equipment costs
- Ultimate goal: Create a program or dashboard that can find the optimal schedule, number of trucks, etc. for any ship entering the port