Container Movement Planning

Analysis of simulation logs

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Outline:

- Scenario and Data Description
- Visualisation of the Data
- Some Data Stats
- Correctness Check
- Some optimization

Scenario description

Scenario: You have just carried out a Simulation for a container terminal in which the customer has provided to us limited data.

Straddle carriers move to their assigned orders, pick the container, move to the order destination, drop the container, and then move to the next assigned order

1. An Excel File was provided by the customer
2. The log file attached is the log file produced by your Simulation-tool that has the following tasks

Based on this data I do some analysis and show some interesting aspects about the data

Description of the data

1. Excel File: three spreadsheets

1. Vehicles:

(ID StartLocation)

2. Locations:

(Location Name X-Coordinate [mm] Y-Coordinate [mm] Capacity limitation (# SC))

3. Container Orders:

(ContainerOrderId OriginLocation DestinationLocation)

Description of the data

2. Logs File: many different log message types

Logs begin from 10:26:30 and end at 11:40:30 on the same day 2024-11-14

1. Vehicle driving msg:

2024-11-14 10:27:10 INFO SC001 (.. CO: CO_TFTU000018, PICK) driving to QC003; 31 s; 172693 mm

(Timestamp VehicleID OrderID LocationID Duration Distance)

2. Vehicle occupying/freeing lane msg:

2024-11-14 10:28:09 DEBUG location QC003: using lane 1 for CO CO_TFTU000008

(Timestamp LocationID LaneNumber OrderID)

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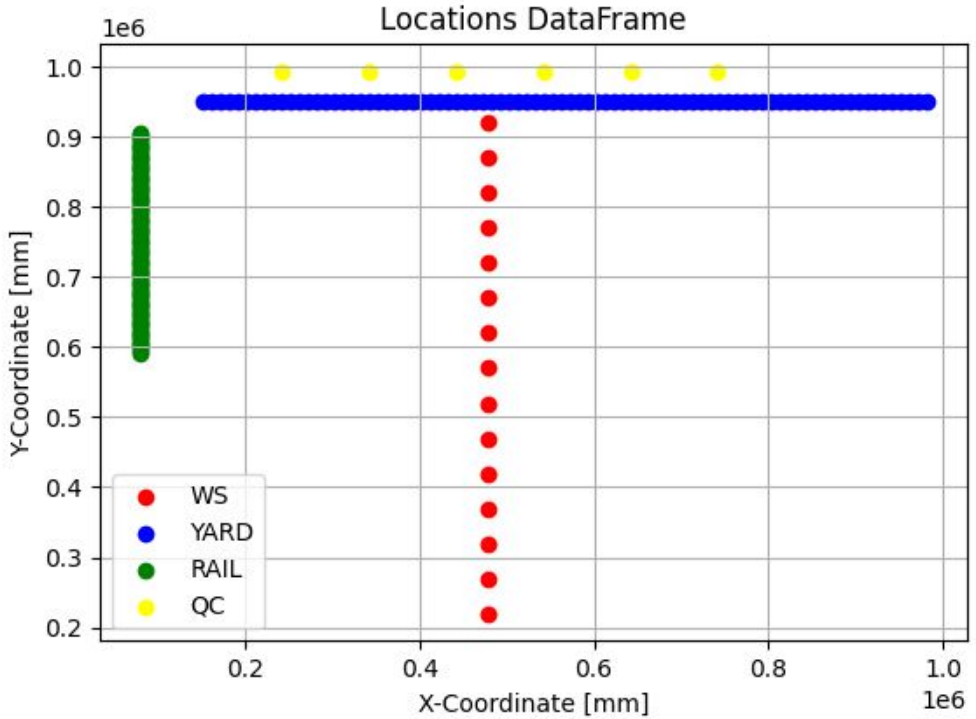
Visualising the Static View

- The Layout of the container terminal
- Distribution of orders: From Origins to Destinations
- Order Paths

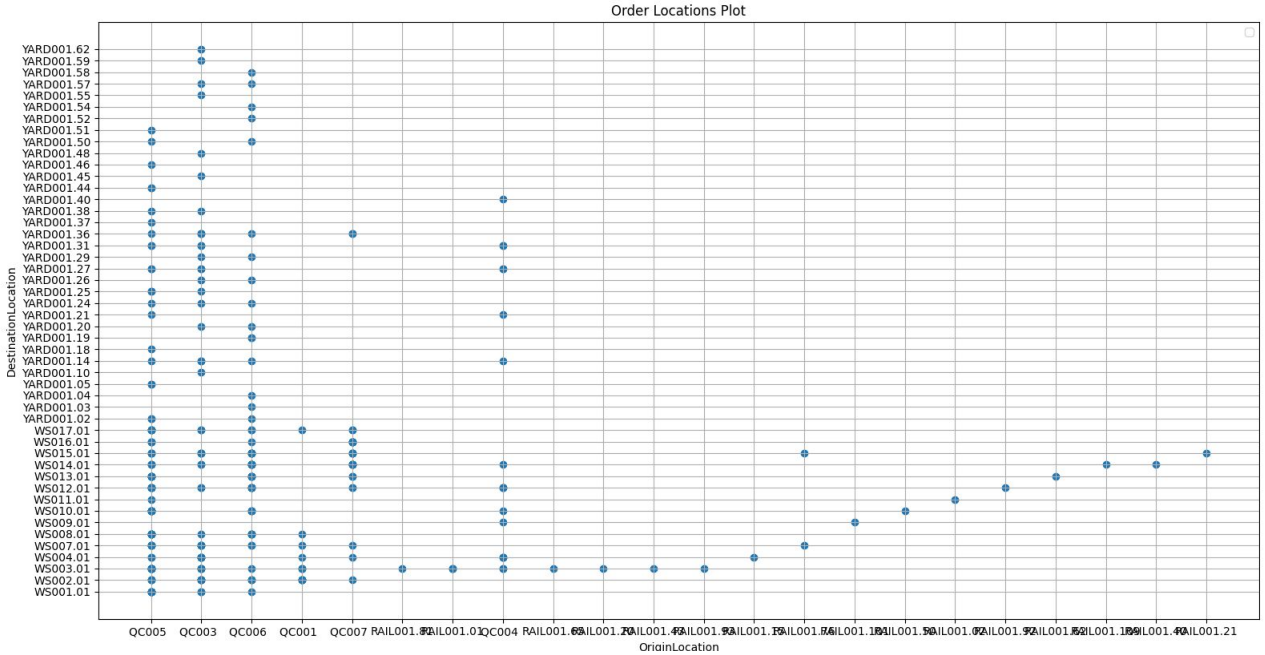
The Layout of the container terminal



Four Different Categories:

- WS (Work Station)
- Yard
- Rail
- QC (Quary Crane)

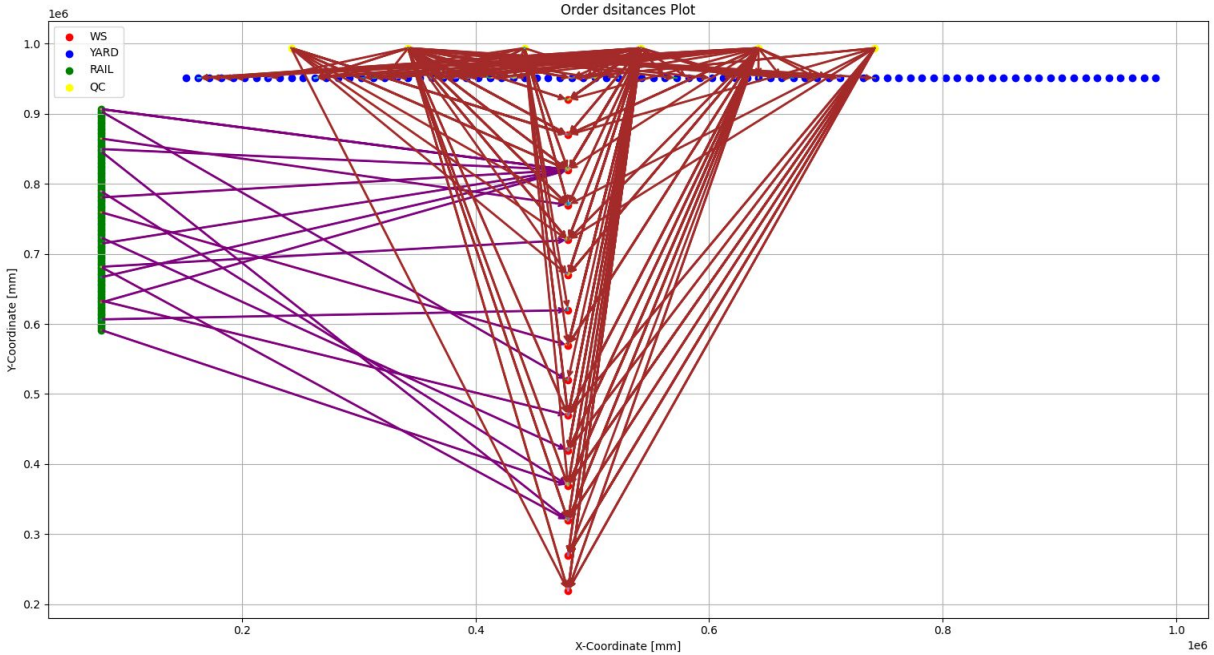
Distribution of orders: From Origins to Destinations



Most Orders Start at the QC locations

QC locations are the most busy

Order Paths



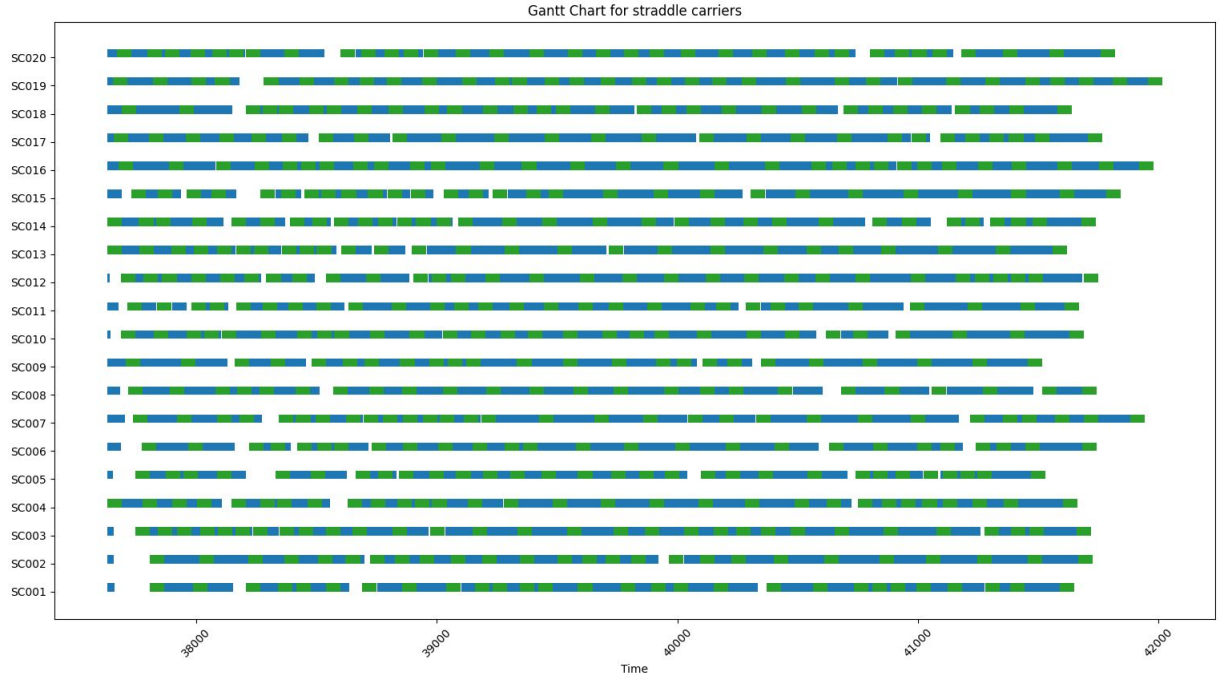
Most Orders happen between the QC and WS locations

Orders suggest that mostly unloading operations are performed

Visualising the dynamic view (simulation results)

- The activity of the Vehicles over time
- The activity of the locations over time
- The path of a Vehicle

Simulation Results: Vehicle Busyness

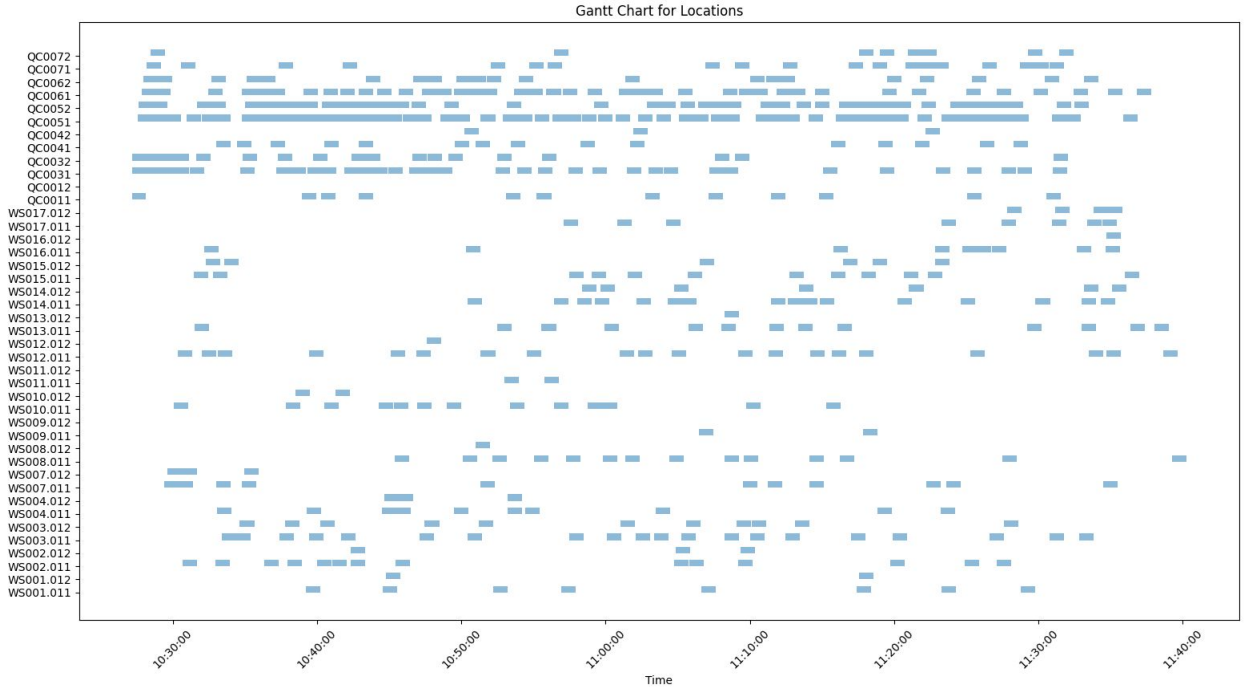


Blue: Driving between locations

Green: Working at terminal

Empty: Waiting at Location

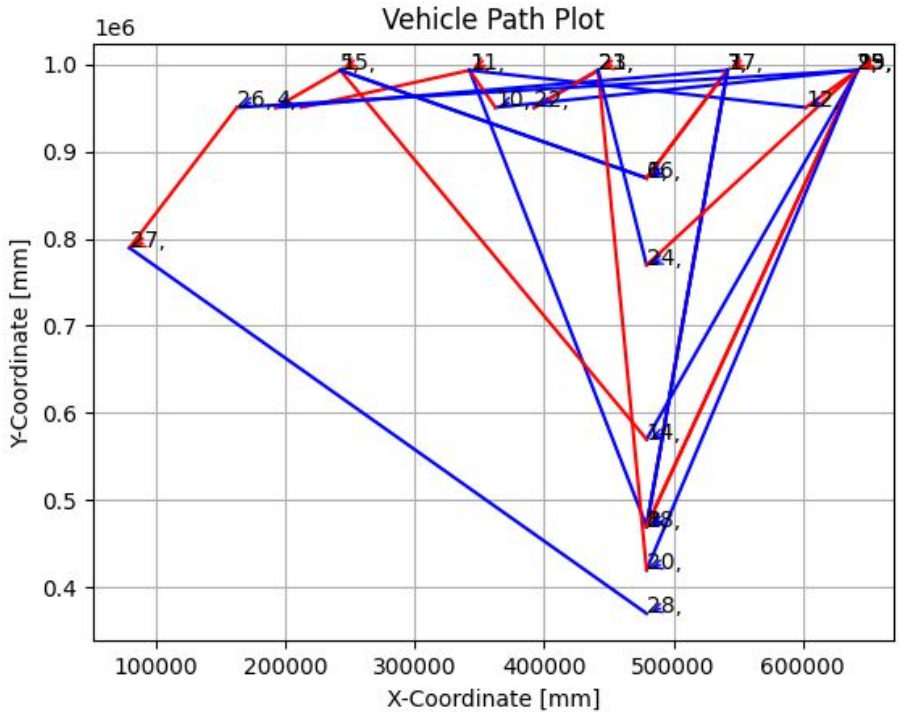
Simulation Results: Location Busyness



Each line corresponds to a lane on one of the locations.

Empty interval mean idle time

Simulation Results: Vehicle Path (SC001)



Blue: Driving to a new order (empty cargo)

Red: Delivering a container to the destination

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Stats for vehicles

	Total distance (mm)	Assigned Orders	Total Waiting Time (s)
V1: SC001	11330100	14	303
…			
Max	14156884 (SC016)	17 (SC020)	357 (SC005)
Min	9654062 (SC005)	12 (SC008, SC009)	0 (SC016)

Stats for locations (QC)

	Assigned Orders	Total Waiting Time (s)
QC001	12	0
…		
Max	97 (QC005)	2214 (QC005)
Min	12 (QC001)	0 (QC001, QC004)

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A correctness check

Verify that no location handles more jobs in parallel than it can handle

Algorithm description (informal):

For each location with limited capacity

- Collect all events happening at the location and sort them
- Check if at each time point if the capacity is exceeded

A correctness check

Verify that no location handles more jobs in parallel than it can handle

1. Using vehicle driving messages

   2024-11-14 10:28:07 INFO SC004 (TO: TO_CO_TFTU000001, CO: CO_TFTU000001, DROP) driving to WS007.01; 92 s; 510685 mm

   Error: Overcapacity found!

   Reason: the duration reported by the log message is inaccurate

   Solution: Use different log message type

A correctness check

Verify that no location handles more jobs in parallel than it can handle

2. Using vehicle occupying/freeing lane messages

2024-11-14 10:28:09 DEBUG location QC003: using lane 1 for CO CO_TFTU000008

2024-11-14 10:29:09 DEBUG location QC003: freeing lane 1 for CO CO_TFTU000008

Result: No Overcapacity!

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Some Optimization: Problem Description

The task is to Schedule a set of orders to a set of vehicles over time to

Minimize

- the total distance travelled
- or the time until all orders are completed

While respecting the capacity of the locations.

Solving the complete problem exactly can be computationally *expensive*,

But the optimizer is only solving the problem in pieces

Some Optimization: optimizing the first step

In the first step, the optimizer is given 55 orders and assigns to each of the 20 vehicles a corresponding order.

Idea: Solve it as an assignment problem (*fast*)

Description: given a set of vehicles and a set of orders,

assign to each vehicle an order so that the total distance travelled is minimized

Some Optimization: optimizing the first step

Description: given a set of vehicles and a set of orders,

assign to each vehicle an order so that the total distance travelled is minimized

$$Z = \sum_j \sum_j d_{ij} X_{ij} \rightarrow min$$

$$\sum_j X_{ij} = 1 \quad for\ each\ vehicle\ i$$

$$\sum_j X_{ji} \leq 1 \quad for\ each\ job\ j$$

$$0 \leqslant X_{ji} \leqslant 1$$

$$for\ each\ vehicle\ i\ ,\ for\ each\ job\ j$$

Results: optimizing the first step

Evaluate the objective value for the assignments from the simulation results

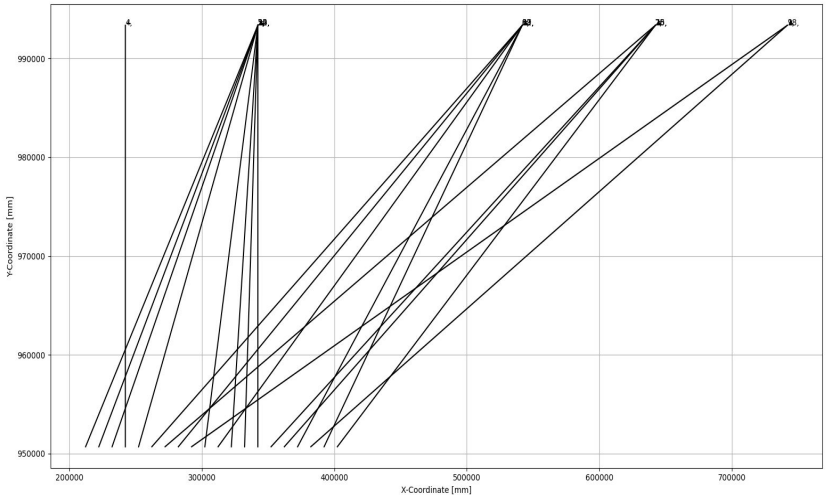
And compare it to the optimal solution

Optimal value: 2275931

Actual value: 4450204

The large difference suggests that there is a room for optimization!!

Idea: use a different optimizer and evaluate the simulation result



plot of the first step assigned to each vehicle

Questions?