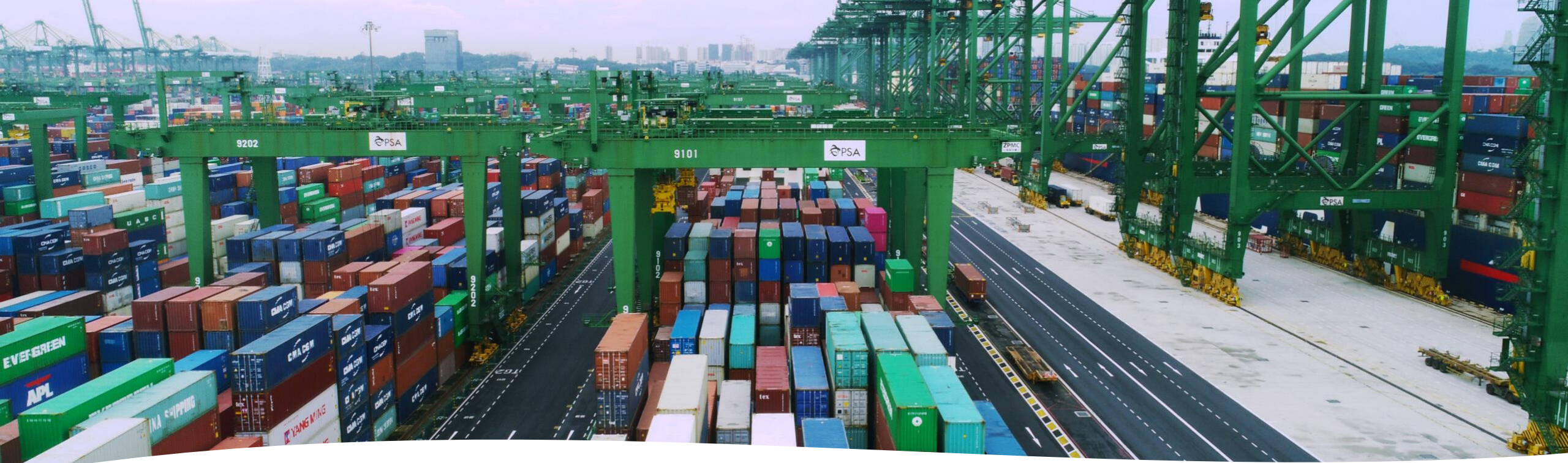


Code Sprint Rundown

Smart Port Operations – AI for Horizontal Transport Optimisation



Problem Statement

- Efficient movement of containers between quay cranes (QCs) and yard is a core challenge in container terminal operations. Horizontal Transports (HTs) must be coordinated under strict spatial, temporal, and capacity constraints, such as lane direction rules, buffer limitations, and service times inside work zones.
- The challenge lies in designing a job scheduling and routing strategy that minimises congestion, balances Yard & QC utilisation, and ensures all jobs are completed in the shortest possible time while respecting operational constraints.

Task

You are tasked to design and test a HT job scheduling and routing strategy that can complete all QC jobs efficiently within the given constraints, based on a simplified terminal setup.

Objectives

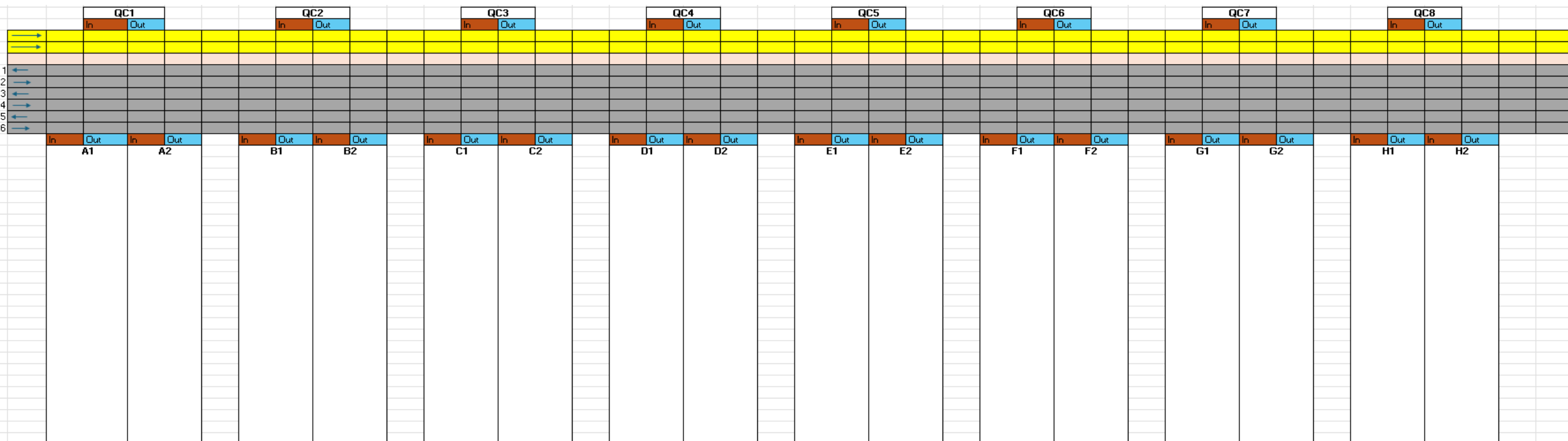
- Complete total of 20,000 jobs (2,500 per QC) using a fleet of 80 HTs in the shortest amount of time.
- Ensure constraint compliance.

Deliverables

- **Performance metrics:** total completion time (before and after)
- **Validation outputs:** confirming that all constraints were respected during the simulation.

Take note: This setup is using a simplified version of operations, created solely for the purpose of this hackathon and does not reflect actual operational processes.

Map Preview



Legend:

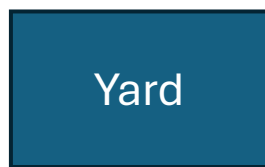
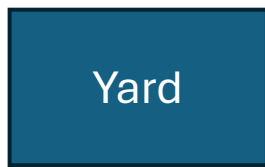
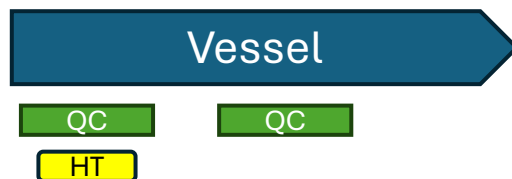
	Unused Zone
	Highway Lanes
	Buffer Zone Lanes
	QC Travel Lanes
	Inlet (into QC/Yard)
	Outlet (into QC/Yard)

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Take note: This setup is using a simplified version of operations, created solely for the purpose of this hackathon and does not reflect actual operational processes.

Basic Concepts of Operations

- Quay Cranes (QCs) and Yard
- Horizontal Transport (HT)
- DI: Discharge (QC to Yard)
- LO: Load (Yard to QC)

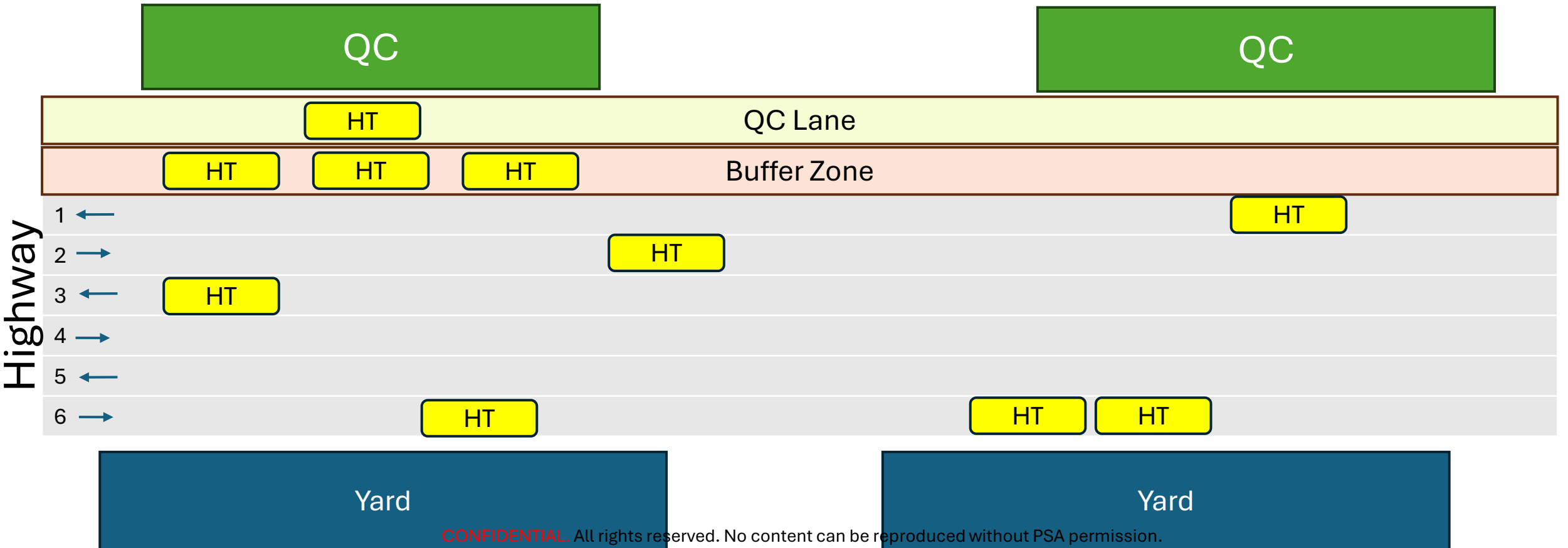


HT



Basic Concepts of Operations

- Buffer Zone
- Highway



Each cell is considered as 1 sector.

Total HT pool set to 80.

Types of Jobs: DI (QC→Yard) and LO (Yard→QC)

Constraints:

1. An HT can only occupy one sector at any given time.
 - a) **Exceptions:** In the Buffer Zone (where up to two HTs can share the same sector/cell)
2. HTs may only move up, down, left, or right.
 - a) **Exceptions:** In QC Travel Lanes, HTs may only move up, down, or right. In Buffer Zone, HTs may only move up or down.
3. A maximum of three (3) HTs may be present in any Yard Block at a given time.
4. A maximum of two (2) HT may be present in each QC Job Zone at a given time.
5. Only colored sectors are considered active for HT operations.
6. HTs must wait in the Buffer Zone if their assigned QC or Yard is still occupied (refer to point 3 & 4)
7. HT must be in a Buffer Zone to receive next job (i.e. it must travel to a buffer sector after completing a job to receive next)
8. Each yard may only handle a maximum of 700 DI jobs.
9. Alternate yard locations are predefined in the dataset under three dedicated columns for each DI jobs; only the listed locations may be used for replanning.

Assumptions:

1. HTs have infinite energy (no charging or maintenance is required).
2. Inlet and Outlet points signify entry and exit of HTs from the QC / Yard and no HT may wait in these spaces
 - a) **Exception:** Unless it is among the 2 or 3 HTs currently being served by the respective QC or Yard.
3. Upon entering a QC or Yard, HTs must complete jobs in sequence:
 - a) By job order at QC
 - b) On a first-come, first-served basis at Yard (based on HT arrival)

The corresponding Handling Duration (see point 7 and 8) must also be executed when HTs are serviced in QC or Yard.

4. HT speed is fixed at 10 secs/sector.
5. Follow the specific direction of the different lanes for traffic in Highway and QC Travel Lanes.
6. In QC Job Lanes, traffic flow is assumed to move strictly from left to right. HTs may only enter or exit the QC Job Lanes via Buffer Zone in upward or downward movement.
7. Handling Duration by QC: 2 minutes per job
8. Handling Duration at Yard: 5 minutes per job
9. Initial starting locations of HTs to be at buffer zone.

Scoring Metrics for Technology

Please ensure your code is runnable **before submission** to be **eligible for scoring**.

Total Time Improvement

- Makespan = $\max(\text{job_end_time}) - \min(\text{job_start_time})$
 - Start of first executed job and last completed job of the QC job list
 - Final vs Baseline: **Improvement Time** = $(T_{\text{final}} - T_{\text{base}})$
 - Baseline time will be given by Team Mentors
-

Hard Rule (Yard Block Capacity)

- **No yard block may exceed 700 DI jobs.** This is a strict constraint, and it must always be enforced with no exceptions.
- **Automatic Consequence:**
 - Any yard block allocation that breaches this maximum of 700-job capacity will be flagged as invalid during scoring stage (after submission).
 - This violation will lead to team disqualification or rejection without further consideration.
- **Take note** that it is the team's responsibility to ensure that each yard block capacity for DI jobs do not exceed the maximum capacity.

Submission Time Priority

If two or more submissions receive the same evaluation score, a tiebreaker will be applied.

Submission time will determine priority:

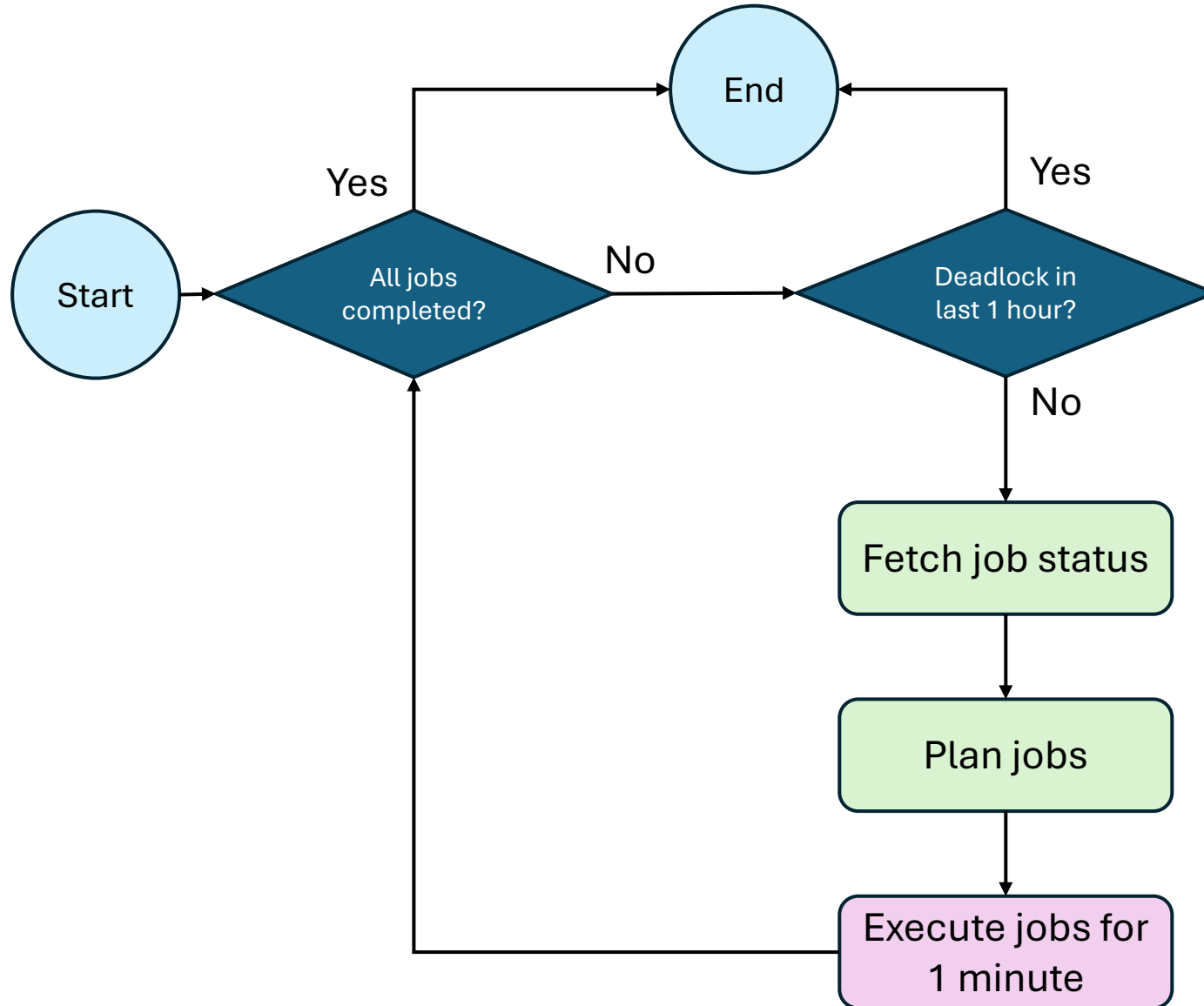
- The submission entered earlier will be ranked higher if same scores are attained.
- In the event of resubmissions, the latest submission of each team will be used.

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Simulation: GUI



Simulation Logic



Planning Engine

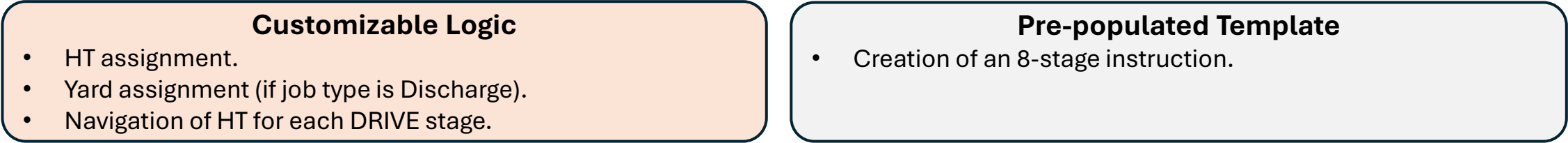
- For each QC, fetch the next 10 jobs in QC sequence order for planning.
- For each plannable jobs, create an 8-stage instruction and feed to Operation's job queue. Note: Once planned, instruction could not be changed.

Operation Engine

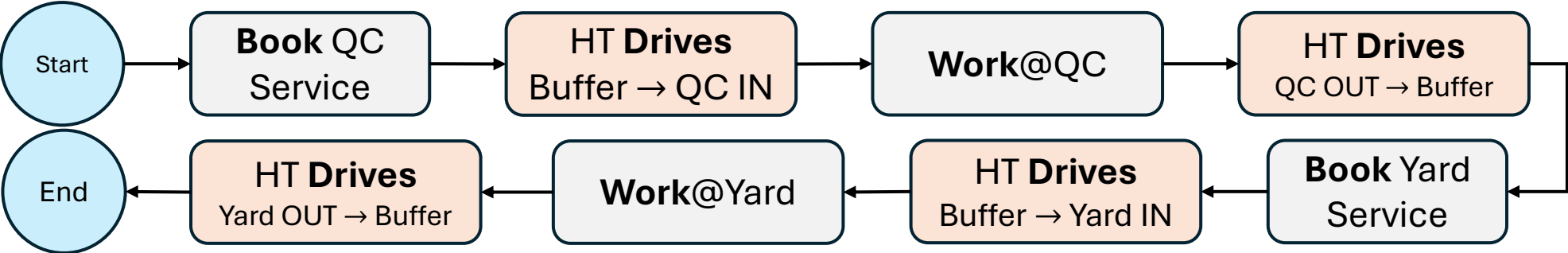
- For each job in queue, check their instruction stage and execute accordingly.
- BOOK_QC/BOOK_YARD: book their service then check for availability. If job's turn is near, proceed to DRIVE.
- WORK_QC/WORK_YARD: start working at QC/Yard.
- DRIVE: move HT based on the path instruction. If 2 HTs move to the same sector, or one blocks the other, HT with smaller serial number moves first and the other to wait for next turn (10 sec).

Job Instruction

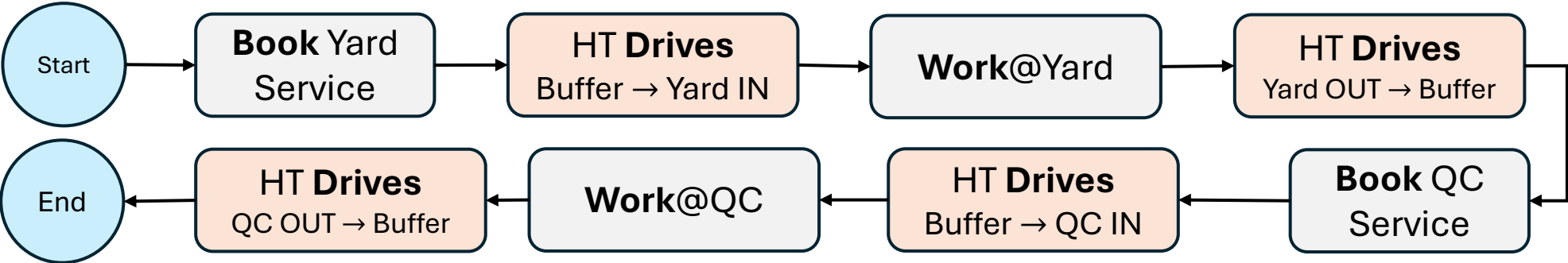
A job instruction includes:



DISCHARGE JOB STAGES



LOAD JOB STAGES



Default Planning Algorithm

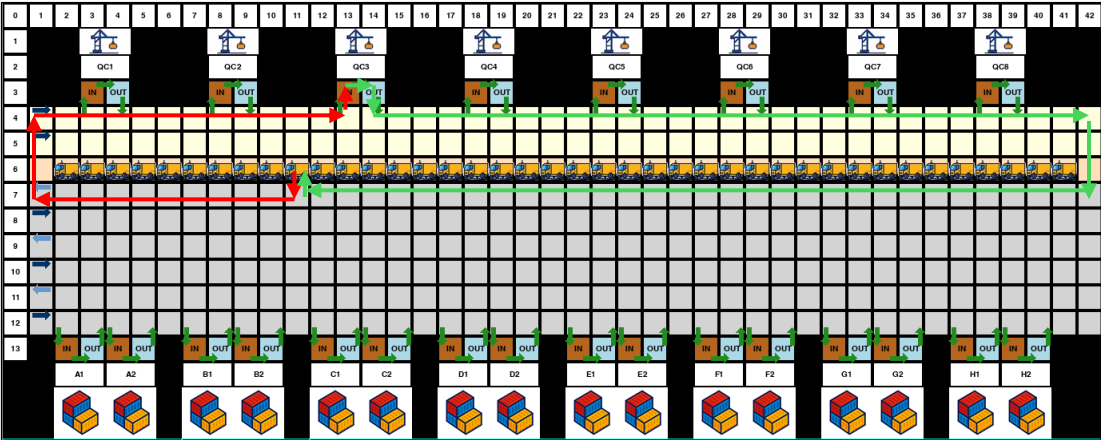
Customizable Logic

- HT assignment.
- Yard assignment (if job type is Discharge).
- Navigation of HT for each DRIVE stage.

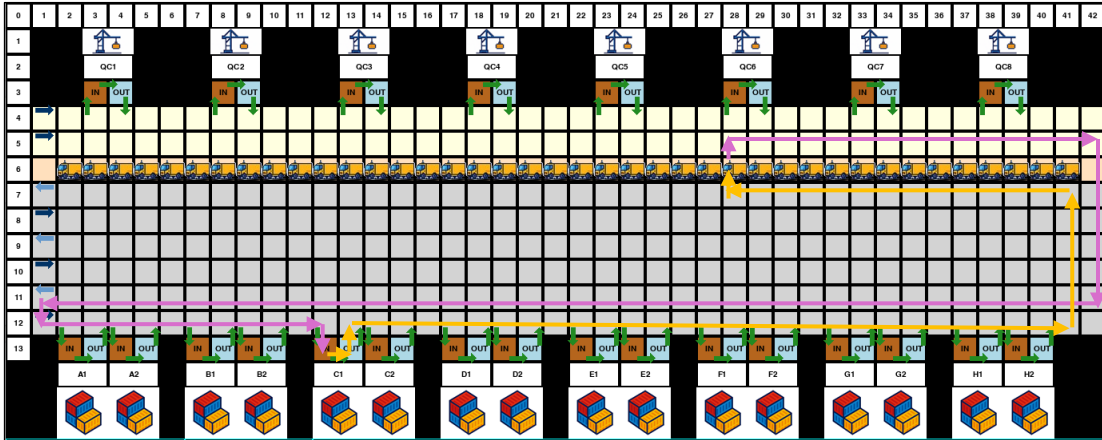
Implementation

- Select left-most HT in Buffer for DI, right-most HT for LO job.
- Use default yard.
- A pre-determined path that ensures dead-lock free.

- Drive from Buffer to QC
- Drive from QC to Buffer



- Drive from Buffer to Yard
- Drive from Yard to Buffer



Input: QC Job List

Sample Dataset:

JOB_ID	JOB_TYPE	CONTAINER_NO	QC_M	QC_JOB_SEQ	YARD_BLOCK	ALT_YARD_BLOCK_1	ALT_YARD_BLOCK_2	ALT_YARD_BLOCK_3
JOB6022768C	DI	CONT5708165Z	QC1	QC1_0001	G2	F2	E1	G1
JOB5002657W	DI	CONT1860335I	QC1	QC1_0002	A2	E1	H1	C1
JOB5258086K	DI	CONT3659128V	QC1	QC1_0003	C1	H2	F1	B2
JOB2271333I	DI	CONT6717804P	QC1	QC1_0004	D2	A2	B1	A1
JOB8759358T	DI	CONT9163683U	QC1	QC1_0005	D2	E1	G2	A1
JOB8310679H	LO	CONT0831003J	QC1	QC1_0006	A1			
JOB8348136W	DI	CONT8500141R	QC1	QC1_0007	B2	B1	C2	F2
JOB9661713U	LO	CONT1305276K	QC1	QC1_0008	E1			
JOB6237088M	LO	CONT4210412L	QC1	QC1_0009	C1			

Column Description:

- **JOB_ID:** Unique job sequence ID
- **JOB_TYPE:** Indicates whether the job is a Discharge (DI) or Load (LO).
- **QC_M:** Unique Quay Crane Name
- **QC_JOB_SEQ:** The sequence order in which jobs are processed at the corresponding QC.
- **YARD_BLOCK:** The Default yard block ID assigned to the job.
- **ALT_YARD_BLOCK<1, 2, 3>:** Alternative yard block IDs that can be assigned for Discharge (DI) jobs. Note that Load (LO) jobs use only the default yard block.

Submission Guidelines

1. YouTube Presentation video explaining your solution.
2. PowerPoint Slides supporting your presentation.
3. Source Code:
 - Modified job_planner.py plus any supporting scripts that depend only on job_planner.py.
 - Other modifications outside of this are not allowed.
 - Zip these files into Codes_TeamName.zip.
 - Include a README.txt describing how to run your code and integrate it into the existing codebase.
4. Simulation Results:
 - data/output.csv
 - the latest log file from logs/ demonstrating your improved results.
5. Team Photos