Container Scheduling and Forklift Routing in Cross-dock

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Project Description

Cross docking is the process of unloading materials from incoming trucks and then directly loading them onto outbound trucks. This project is to assist IDSC in building cross docking scheduling software to manage cross docking operations.

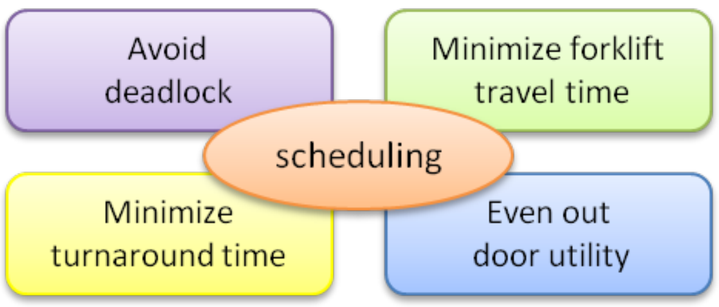
Project Objective

- Implement an algorithm to assess the feasibility of crossdocking operations at the chosen site
- Sequence and assign inbound containers to docks
- Design routes of forklifts

Container scheduling

- **Methodology**: Graph coloring is used to efficiently solve the sequencing problem. A modified degree-based graph coloring algorithm is used because traditional graph coloring algorithms have several limitations that restrict its application to this problem. For example, deadlock might occur when traditional graph coloring algorithms are naively applied to this problem and containers will be unable to enter or leave. In addition, traditional algorithms do not allow us to decide on desired levels of utilization for each door.

- **Challenge:** Scheduling has multiple objectives and our program has to strike a delicate balance between them.

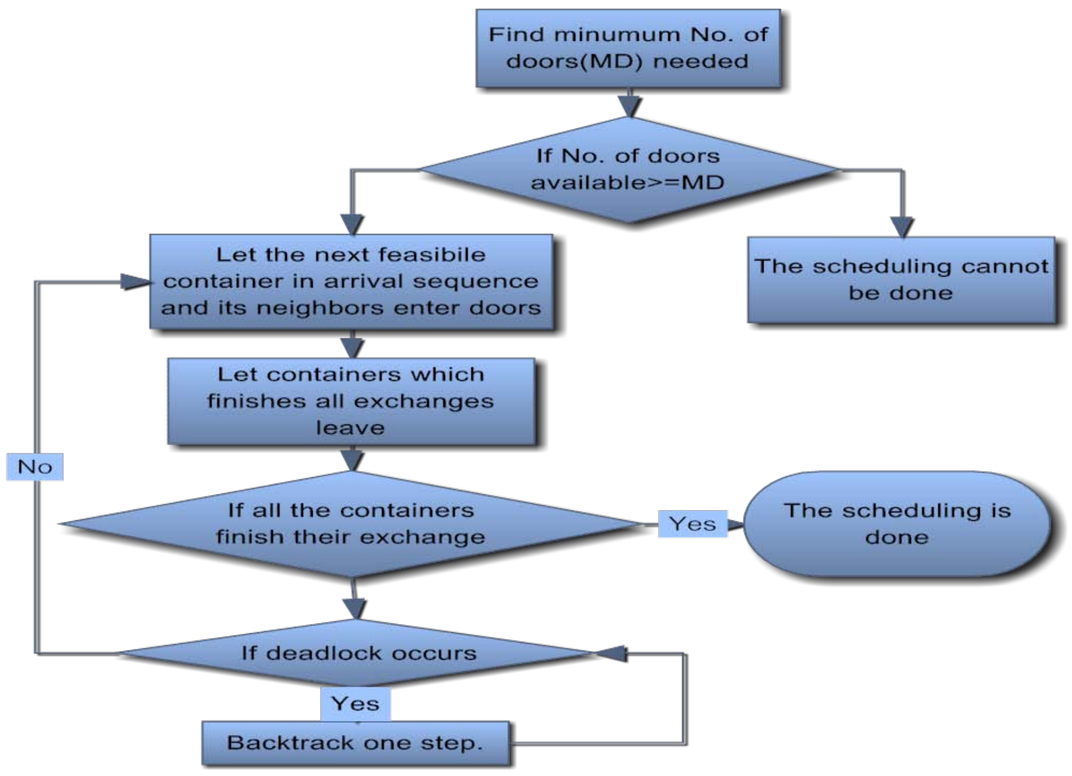


•Keep record of all sequencings tried in previous stages, and backtrack one step should deadlock occur
•Use weighted score to measure both proximity and utility

$$\lambda_1 * \frac{utilization\_of\_Door\_i}{\sum_j utilization\_of\_available\_Door\_j} + \lambda_2 * \frac{proximity\_of\_Door\_i}{\sum_j proximity\_of\_available\_Door\_j}$$

•Enter the containers according to their arrival sequence

- **Heuristic:**



Solution to container scheduling

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- Container ID: CC13X has left the Crossdock from Door 12.
  - Number of Pallets Exchanged: 7
  - Minutes Spent in Crossdock: 53

- Container ID: XY28G has entered Door 12.
  - Number of Outbound Pallets: 3
  - Number of Outbound Pallets: 5

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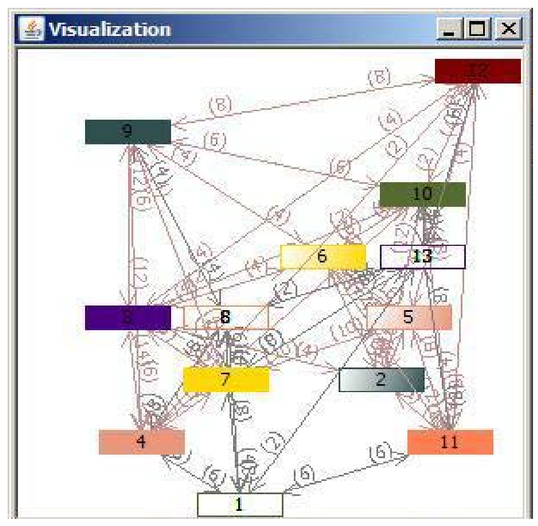
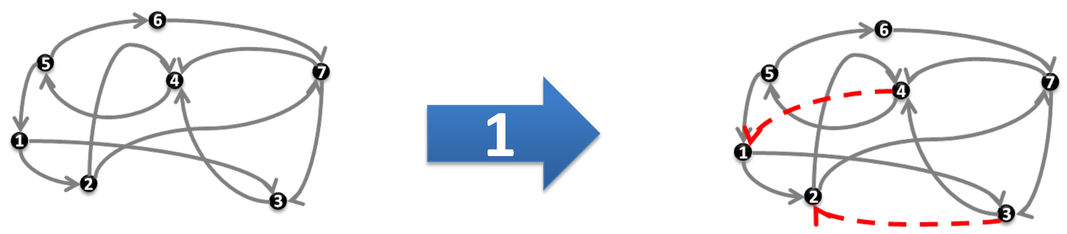


Each node in the picture denotes a container. The color of the node indicates the door that it is assigned to, and it changes as the exchanges are processing
Gradient color – container waiting to enter the door
Solid color – container in door, pallets being exchanged
White color - exchanges done, container left the door

Forklift routing

- **Methodology:** Our forklift routing algorithm is also inspired by insights gleaned from graph theory. An Eulerian path is the path that traverses each edge of a graph only once and is the most efficient way to traverse a graph. We route our forklifts such that they describe an Eulerian path through the crossdock.

- **Process to find a Eulerian path**



1. Add edges to strongly connect the graph
2. Find the Eulerian trail
3. Divide the Eulerian trail into sections of equal length and assign forklifts to the sections of the Eulerian trail to minimize the total distance travelled

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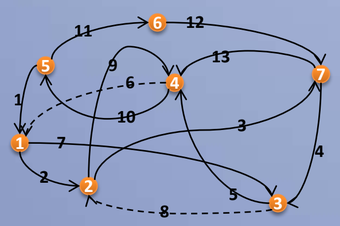
Solution to forklift routing

Stage\Forklift	A	B	C	D
Stage 1	1-3-7	3-4-1	2-7-3-4	5-3-2
Stage 2	7-2-4	6-7	1-2-7-5	4-5-7
Stage 3	4-5-1-3	7-4-5-1	5-6	3-1-6



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Stage 1	1-3-7	3-4-1	2-7-3-4	5-3-2
Stage 2	7-2-4	6-7	1-2-7-5	4-5-7
Stage 3	4-5-1-3	7-4-5-1	5-6	3-1-6

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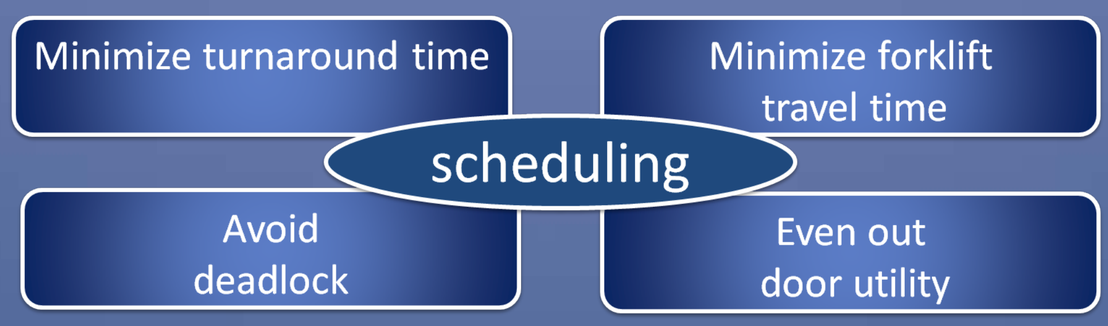

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Stage 1	1-3-7	3-4-1	2-7-3-4
Stage 2	7-2-4	6-7	1-2-7-5
Stage 3	4-5-1-3	7-4-5-1	5-6

- Add artificial edges to strongly connect the graph
- Find the Eulerian trail using off the shelf algorithms
- Divide the Eulerian trail into sections of equal length according to the number of forklifts
- Assign forklifts to the sections of the Eulerian trail to minimize the total distance travelled