







Special Session on Modeling and Analysis of Container Terminal Operations





MARLOG 4 A Sustainable Development Perspective for Mega Projects

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World Seaborne Trade Trends

Development of Containerized Trade



Source, UNCTAD, REVIEW OF MARITIME TRANSPORT 2014

The Suez Canal Corridor

- Suez 21 "the Suez economic corridor" is going to provide Egypt a fully integrated system of trade, industry, transport, logistics, and technology within a dynamic region, supported by rail, air, manufacturing clusters and a cluster of container terminals and ports.
- Developing the Suez Canal corridor will transform Egypt into one of the world's leading logistics hubs connecting European, Asian, and African markets.
- This will result in increased container traffic in all ports of Egypt.









Container Terminal Operations

- A container terminal is an intermodal interface that usually connects container vessels on sea with trucks on land.
- One of the main performance measures of a port container terminal is the turn-around time or service *time* at the port including:
 - berthing,
 - unloading,
 - Loading, and
 - Departure.
- Minimization of turn-around tipe
- Optimization of resource scheduling & utilization
- Optimization of container stacking & handling









Container Yard Planning Decisions (CYPDs)



Container Terminal Team in EJUST



Special Session Topics

- The Industrial Engineering and Systems Management team of the Egypt-Japan University of Science and Technology (E-JUST) will cover some aspects of the following container terminal planning and management decision problems:
 - Berth allocation.
 - Quay crane assignment.
 - Transportation trucks allocation.
 - Container pre-marshalling.
 - Container terminal simulation.

Acknowledgment

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Introduction to Container Terminal Planning and Operational Decisions





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Outline







Container Yard Planning Decisions

Berth Allocation

Quay Crane Assignment and Scheduling

Storage Space Allocation

Container Pre-marshalling

Planning and Scheduling of Equipment







Hierarchical Relations Between CY problems



Zhang et al. 2003 (5)

Complexity of Container Yard Planning Decision Problems

- The need for optimization using methods of operations research in container terminal operation has become more and more important in recent years.
- This is because the logistics especially of large container terminals has already reached a degree of complexity that further improvements require scientific methods.
- The impact of concurrent methods of logistics and optimization can no longer be judged by operations experts alone.
- Objective methods are necessary to support decisions.
- Such decisions are nowadays unthinkable without the effective and efficient use of information technology as well as optimization and operations research methods (Steeken et al 2004²).





Analytical Closed Form Solutions

- Decision Variables:
 - Quantities transported from each ship (A, B, c) to each yard $(1,2,3,4,5,6) = X_{A1}, X_{A2}, ..., X_{ij}, ..., X_{C6}$
- Objective function
 - Minimize $\Sigma C_{ij} X_{ij} = 60 X_{A1} + 70 X_{A2} + ... + 40 X_{C6}$
- Constraints, Ship supply
 - Ship A: $X_{A1} + X_{A2} + X_{A3} + X_{A4} + X_{A5} + X_{A6} \le 100$
 - Ship B: $X_{B1} + ... \le 120$
 - Ship C: X_{C1} + ... ≤ 80
- Constraints, Yard Capacity
 - Yard 1: $X_{A1} + X_{B1} + X_{C1} = 40$
 - Yard 2: $X_{A2} + X_{B2} + X_{C2} = 70$
 - Same for Yard 3, 4, 5, 6







Excel Solver





15

Heuristics and Meta-heuristics

- Metaheuristic designates a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality.
- Metaheuristics make few or no assumptions about the problem being optimized and can search very large spaces of candidate solutions.
- However, metaheuristics do not guarantee an optimal solution is ever found.
 - Graph search methods
 - Blind search
 - Informed search
 - Trajectory search methods
 - Simulated annealing
 - Tabu search
 - Evolutionary methods: Genetic algorithms
 - Swarm intelligence: ants colony, PSO

<figure>









Discrete Event Simulation

- In discrete-event simulation, the operation of a system is represented as a chronological sequence of events.
- Each event occurs at an instant in time and marks a change of state in the system.
- Examples of general simulation software:
 - Arena, Promodel.
- Dedicated simulation library for container Terminal Simulation:
 - FleXsim CT.
 - Chesscon (ISL).









CYP Decisions

Berth Allocation Problem (BAP) Quay Crane Assignment (QCAP)

Problem Description

• The problem of allocating ships to the proper quay locations is referred as the Berth Allocation Problem (BAP).







Quay Crane Assignment Problem (QCAP)

- A feasible berth plan and a set of identical QCs are given.
- For all the vessels included in the berth plan, the volume of containers to be loaded and/or unloaded is known as well as the maximum number of cranes allowed to serve it simultaneously.
- The problem is to assign cranes to vessels such that all required transshipments of containers can be fulfilled





Integrated BAP, QCAP, QCSP

- BA, QCA, QCS decisions can be made in a sequential fashion. This way the overall problem complexity of seaside operations planning is broken down into a series of decisions.
- Imai et al (2008) illustrated the simultaneous berth and quay crane allocation problem that minimizes the total service time and a genetic algorithm based heuristic based solution.







CYP Decisions Storage Space Assignment and Location Assignment









CYP Decisions

Container Pre-marshalling

Problem Definition

Objective









The optimization goal is to minimize the number of movements required to transform the container yard from its initial layout to its final layout.

Outputs

 The optimum Sequence of containers movements to reach the desired layout







Container Pre-marshalling







Complexity of scheduling

- The scheduling problems in container yard are:
 - Multi-objective
 - Complex
- Scheduling problem for loading or unloading containers is also NP-hard.
- Therefore, the optimization of the operation is <u>too</u>
 <u>complex</u> to be solved by mathematical programming model alone.
- Therefore, there are two approaches for solving this problem:
 - Scheduling for each set of equipment separately (QC scheduling is the most important)
 - Solving the problem using Simulation tool.

Simulation Modeling and Analysis of Container Terminals

Conclusion

- Eng Ahmed Karam, MSc
 - Allocating Berths, Quay Crane And Internal Trucks In Container **Terminals**
- Dr Mohamed Gheith, PhD Container pre-marshalling
- Eng Omina Reda, Bsc
 - Container Terminal Modeling and **Analysis using Discrete Event** Simulation

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Thank you !