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# A MODELING AND SIMULATION PLATFORM FOR EVALUATING OPTIMIZATION METHODS IN CONTAINER TERMINALS

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## ABSTRACT

Container terminals are expanding and increasing by the year, due to the enormous demand on world trade and cargo exchange in the last couple of decades. Port authorities are seeking different methods to assess and analyze these expansions, without putting themselves at risk; correspondingly they resort to simulation and optimization methods to evaluate and consider future expansions and developments. In this research, a discrete-event simulation model for a modern container terminal will be developed; then the developed simulation model will be utilized to study and analyze critical optimization issues that are usually encountered in container terminals.

## 1 INTRODUCTION

Throughout the last two decades, maritime trade and economics have shown a continuous incline that was naturally coupled with an increase in the number of freight containers transported around the world; therefore, more maritime ports are being established to cope with this increase. A maritime port consists of multiple terminals with specific functionalities and specialized equipment. A container terminal is one of the many facilities in a port, that involves numerous resources and entities. It is also where containers are stored and transported, making the container terminal a complex system. Issues such as berth allocation, quay crane scheduling and assignment, storage yard layout configuration, container re-handling, customs and security delays, and risk analysis become challenging.

Operations research and mathematical algorithms can provide near optimal solutions for problems that are usually faced in a container terminal. Whereas simulation can be a useful tool to assist in predicting the behavior of the system and its performance under unforeseen circumstances as well as to study possible modifications to the components of the port system.

## 2 RESEARCH PURPOSE AND OBJECTIVES

The purpose of this research is to develop a testable maritime container terminal discrete event simulation model to provide a platform where various optimization algorithms can be applied and tested in order to improve efficiencies in a container terminal. The analysis will entail studying various scenarios motivated by applying different optimization algorithms and changing different parameters to achieve port activities improvements. This model will provide solutions for modern container terminal problems, like bottlenecks, crane/berth scheduling/assignment problems and resources allocation. The simulation will aid in evaluating the performance of different heuristic algorithms and mathematical applications for various problems within the container terminal in order to improve port activities, optimize performance measures and ultimately reduce cost.

The contribution of this work revolves around two objectives: the first one is to develop a discrete-event simulation model for a modern container terminal, including operations, logistics, processes and resources; and the second objective is to use the developed simulation model to study and analyze critical optimization issues that are usually encountered in container terminals. Hamad container terminal, a modern terminal located in Doha, Qatar will be used as a case study to evaluate the proposed research.

## 3 METHODS

The first part of this research is to develop a discrete event simulation model using the simulation software Arena 14.7 to model a container terminal that can be utilized to study the different operations and the flow of incoming and outgoing containers and resources in the terminal.

To create a simulation software that can mimic the real system, the port is to be thoroughly studied and its operations, components, resources and schedules are to be comprehended. Data is to be collected related to port activities, operations, resources, capacity, dimensions and more. Investigating the design of such complex model is therefore an essential step toward achieving the other goals of this work, thus a conceptual model will be constructed to facilitate the building and the understanding of the simulation model.

In order to translate the conceptual model into a virtual system that would truly represent the real system, the entities and resources must be defined. The next step will be to outline and understand the different main cycles that usually take place in a container terminal where containers are transported.

In order to validate the constructed simulation model, data should be collected from the system under study to represent the main system performance indicators such as: number of handled containers in a year, average waiting time in queue, average utilization, and others.

After constructing the model and collecting results of the applied settings, sensitivity analysis will be performed to study and simulate different scenarios for purposes of increasing utilization and improving performance. These scenarios will include changing the number of resources, capacities, location etc. Then results will be studied, analyzed and compared to the original scenario.

## 4 OPTIMIZATION

The second part of this research is to develop optimization models and algorithms to solve some of the problems usually encountered in container terminals. After constructing and validating the simulation model, it will be used as a tool to assess and evaluate the different optimization methods that will be applied to these problems and to simulate their impact on the port activities and operations.

Some of the important optimization problems that will be considered are, the berth and quay crane allocation problem, the quay crane scheduling problem, resources handling time minimization, storage yard resources allocation/scheduling/assignment and storage yard configuration and layout. The exact problems will be identified during the course of research and will be based on the research gaps in the literature.

## 5 RESEARCH PLAN

Container terminals are considered complex systems, since they consists of multiple different smaller systems, each with its own operations, cycles, bottle necks and schedules making decision-making challenging and risky. Therefore, to improve the decision making process in container terminals and to avoid the risk of implementing new strategies without testing them; this work aims to develop a discrete-event simulation-optimization model that mimics the container terminal and its operations.

The initial work will be concerned with developing a generic port simulation model that can be configured to simulate modern ports. Then after verifying and validating the model, it will be utilized to capture the stochastic elements of a specific port to analyze them and support decision making in the port. Finally the simulation model will be employed as an evaluation tool for solving and assessing optimization problems.