AN OPTIMIZATION MODEL FOR BLOCKS ALLOCATION TO SERVICE VESSELS IN A PORT CONTAINER TERMINAL

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I would like to dedicate this dissertation to my beloved father and mother, Jahanbakhsh Nasrollahpourniazi and Mahin Rahgozar who taught me with their love, how to be strong on hard days with hopeness to better life. I also dedicate it to my dear teacher, Seyed Hassan Saviz who learnt me how kind is our Allah.

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ABSTRACT

This study developed a new mathematical model on allocation of cargo of a service in a port's container terminal. The objective of the project was minimizing the oveall distances between vessels in berth and blocks in yard side. Each service had some data. The service in operation concepts in the port had three groups of participants: 1) Discharging vessels, 2) Cargo by the number of containers, 3) Loading vessels. The containers were discharged from vessels to yard blocks by trucks then loaded to next vessel. Each truck could transfer one container at a time.The purpose of this project was finding the best blocks between all available blocks in port to minimize the overall distances which the trucks had to pass for discharging or loading. Solving this problem had other important benefits for reducing the port costs, like minimizing the fuel usage by trucks, minimizing the staying time of the vessels at the port, and consequently improving the quality of the port service, which in today's competitive market would retain and absorb customers. There were only two input data for the problem: 1) the availability of the yard blocks, and 2) the number of containers in each service (either discharging or loading) and the location of the vessel in which berth. The method used in this project was Mixed Integer Linear Programming to mathematical modelling and solving by GAMS software. The distance between berth to blocks was divided into three distances. The Momentum formulation was used to find a point in the berth, which considered the number of containers as the forces and the berth as the location. The point was transferred to the yard then all blocks were prioritize by the nearest distance to this main point in the yard side. Then the needed blocks should be chosen from all the nearest blocks. The research was done based on the data from the 17^{th} busiest port in the world, port of Tanjung P located in the south of Malaysia.

ABSTRAK

Kajian ini bertujuan mengembangkan satu model Matematik baru dalam penetapan servis kargo dalam terminal kontena pelebuhan. Objektif projek ini adalah antuk mengurangkan jarak yang perlu dilalui antara kapal di dermaga ke blok-blok penyimpanan.setiap servis mempunyaibeberapa data. Servis dalam konsep operasi di pelabuhan mempunyau 3 kumpulan: 1) Pemindahan dari kapal, 2) Kargo mengikut bilangan kontena and 3) Pemindahan ke kapal. Kontena dipindahkan dari kapal ke blok-blok simpanan menggunakan trak dan kemudian dipindahkan ke kapal lain. Setiap trak boleh memindahkan satu kontena pada satu masa. Tujuan projek ini adalah untuk menentukan blok paling tepat daripada blok-blok kosong untuk meminimakan jarak perjalanan yang perlu dilalui oleh trak dalam memindahkan kontena. Penyelesaian masalah ini dapat memberi manfaat dalam mengurangkan kos pelabuhan, seperti meminimakan penggunaan bahan bakar trak, meminimakan jangkamasa kapal berlabuh, dan seterusuya meningkatkan kualiti servis pelabuhan. Dalam persaingan pada hari ini, kualiti akan meningkatkan dan mengekalkan pelanggan. Terdapat 2 input data untuk masalah ini: 1) Kekosongan blok-blok simpanan, 2) Bilangan kontena di steiap servis (pindah turun dan naik) dan lokasi kapal di ruang dermaga Metodologi yang digunakan dalam projek ini adalah “Mixed Integer Linear Programming” antuk model Matematik dan penyelesaian menggunakan perisian GAMS. Jarak antara dermaga ke blok dibahagikan kepada 3 jarak. Formulasi “Momentum” digunakan untuk mendapatkan satu titik di dermaga, mengambil kira bilangan kontena sebagai daya dan dermaga sebagai lokasi. Titik ini dipindahkan ke blok simpanan dan blok-blok diberi keutamaan berdasarkan jarak terdekat ke titik ini. Kemudian blok yang diperlukan akan dipilih dari blok-blok yang paling hamper. Kajian ini dijalankan berdasarkan data daripada pelabuhan ke-17 paling sibuk di dunia, Pelabuhan Tanjung Pelepas di Selatan Malaysia.

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PTP	-	Port of Tanjung Pelepas
TEU	-	Twenty foot Equivalent Units

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Transportation has been done by airplanes, vessels, trains, and trucks. Transporting goods by vessels is an important issue as it effects the international trade in terms of cost, time, and accessibility. Global trade is also affected by ports, which are the service sectors for loading and discharging containers. Berthing duration of a vessel depends on the number of containers to be loaded and discharged from the vessel, the planning of the transferring form vessel to yard, and from yard to vessel. When vessels have appropriate plans for this process, the stay time at ports would be minimized so ports serve more services. In this case, the quality of services also improves.

In this process an important issue of consideration is knowing how many containers a terminal can handle. In this regard, Berth is come to know as a critical issue, mainly because it is more expensive to build compared to any other facilities at docking sites.

One important issue is transferring containers between yard side and berth side. This process should be done by minimum use of energy, such as time and fuel. Therefore, ports scheduling is a complex problem. Mathematical modeling has been found useful to overcome this complexity.

For the purpose of this research the port of Tanjung Pelepas (PTP) was observed. Then industrial engineering techniques for making critical decisions were used to help the manager of this service sector for the development of the port. PTP is located in the south of Malaysia. This terminal is ranked as the 17th busiest ports in the world.

This chapter presents the background of the study, problem statement, objectives of the study and its scope.

CASE STUDY: PORT OF TANJUNG PELEPAS

The Port of Tanjung Pelepas (PTP) in Malaysia was established for container vessels in the south-west part of the state of Johor on the eastern side of a river called Pulai as it is shown in Figure 1.2 which is the map picture of PTP and its location in the Malaysia's map.

The very first vessel came to this port on October 10th, 1999 to establish a three-month trial operation. This port has been known as the fastest growing port with 1 million twenty-foot equivalent units (TEU, a unit for cargo capacity). After a satisfactory trail operation, this port was launched by Tun Dr. Mahathir Mohamad on 13 March 2000, who was the Prime Minister of Malaysia at that time. Figure 1.1 is the high view of PTP and shows the berth sides with quay cranes and the blocks in the yard side.

Figure 1.1 High view of PTP

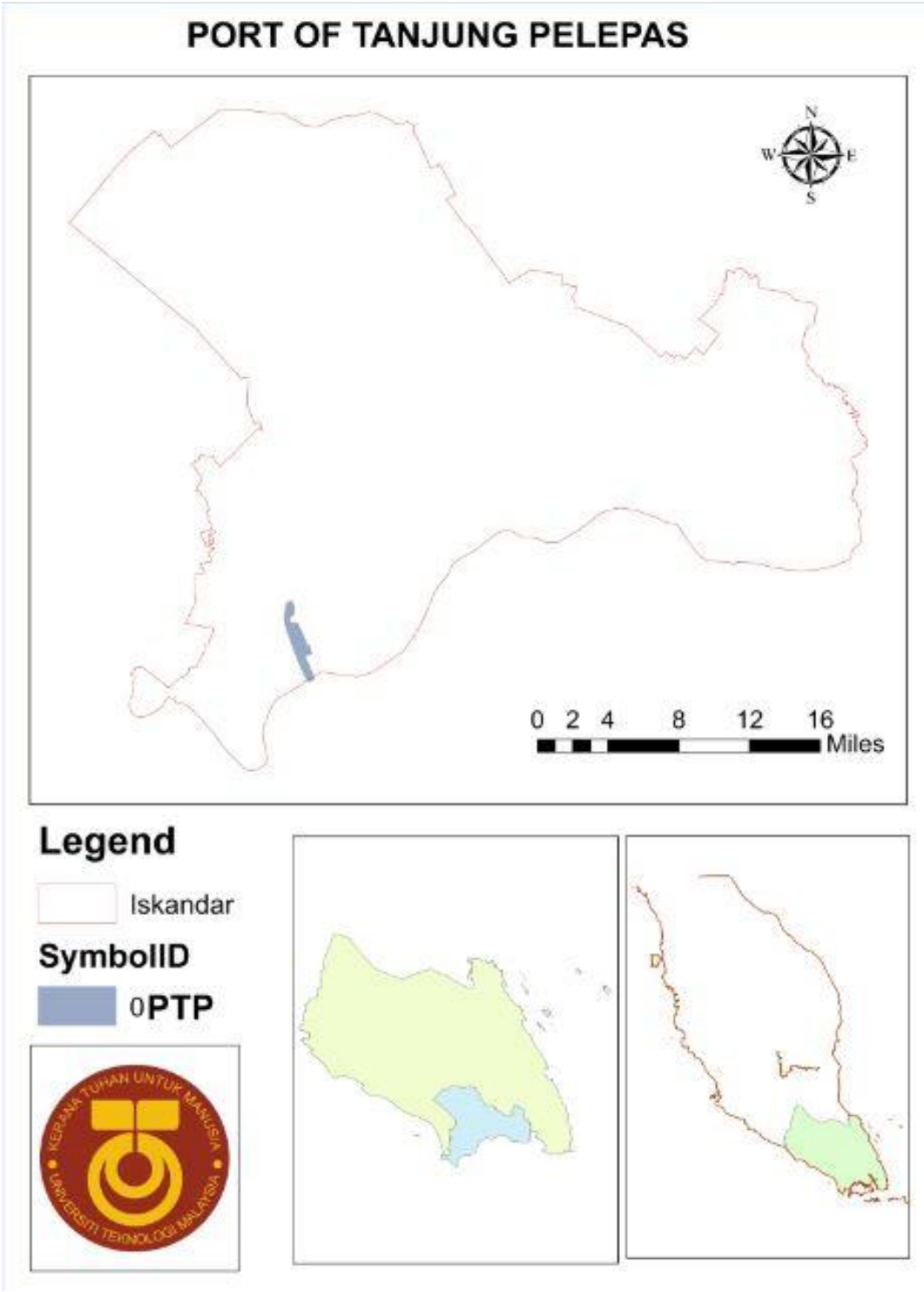

Figure 1.2 The map of PTP

PTP has been a fast developing port and as a result has turned into an alternative choice to Singapore's terminal. Its sustained growth after 2000 was also largely possible as Maersk Sea land, the world's largest container ship operator, took a 30% equity stake in the port's holding company, Seaport Terminal in a deal concluded on 17 August 2000, effectively shifting all of Maersk's operations to the new port from the Singaporean port by the end of that year. Maersk was once the largest operator in Singapore, and the shift represented a 10% drop in business there.

In 2002, Evergreen Marine Corporation, the world's second largest shipping company after Maersk, also shifted its operations to PTP from Singapore. This event raised alarm bells in the Singaporean port with widespread speculation in the shipping community that Evergreen's endorsement of PTP demonstrated that Maersk's move may not be an isolated one. Other lines have since also started direct services at PTP.

Besides being connected directly to the main Malaysian expressways, the port is also linked to rail access which extends into Southern Thailand with a 4 track rail terminal. A 14 lanes gate terminal and 6 lanes FTZ (Free Trade Zone) ensure a smooth turnaround time for import and export containers. The port development area consists of 2,000 acres for the port terminal and 1,500 acres for the free trade zone.

Loading and discharging is done by 14 berths and 44 cranes. The berth is divided into two main parts: (1) Sea side, and (2) land side (Yard).

Due to the limitation of space at the sea side of the port, some vessels cannot get service and are lost. This is because some other vessels are waiting to be served and there is no more area for these vessels to stay and wait for service. These vessels are considered lost vessels and may do loading and discharging at other near ports, such as Singapore port.

1.2 Problem Statement

International sea transportation has grown dramatically over the past decade and container terminals has become key factors in global shipping network. Initial methods of port scheduling entails costly time and motion studies. Therefore, it is important to optimally use available facilities at ports to cut huge costs of service developments.

For the purpose of this research a real problem was identified at port of Tanjung Pelepas in the southern part of Malaysia. The investment in yard planning department in Tanjung Pelepas has determined that the main issue in this particular port is to find a systematic way of decision making about the proper location of blocks for each service. In fact, the problem was transferring containers from discharging vessels to yard with minimum distance between berth to yard.

Generally, vessels bring a group of containers to be discharged at the port. Then the containers are positioned on the spaces in the yard and then are collected from those spaces and transferred to loading vessels to leave the port. Transferring the containers from vessel to block and from block to vessel is done with trucks one by one. In this process the minimizing the cost of fuel for trucks is one significant issue. Another issue is minimizing the conjunctions of trucks in the port terminal. The last issue is minimizing the total distance that trucks cross to transfer containers.

The word “service” in this research refers to any sets of cargo which would be discharged and loaded by vessels. In order to place a cargo on blocks in the yard, this research aimed at determining a position with minimum distance between all vessels.

1.3 Objectives of the Study

Based on the mentioned problems in this particular case study, this study was conducted, with the following objective:

- To develop a mathematical model to minimize the distance between vessels in berth side to chosen blocks in yard for each service.

1.4 Research Questions

In line with the objective of this research, the following research questions are defined.

i. Which blocks in the yard side are the best positions for locating a cargo?

ii. How the total distance between vessels and blocks should be calculated to be the minimum distance?

iii. What is the effect of each vessel –from the two aspects of (1) positioning in the berth, and (2) the number of containers each vessel brings- on the chosen blocks in the yard?

1.5 Significance of the Study

The importance of this research in port is to optimize resources not only to decrease service time and fuel costs, but also to improve the quality of services. This optimization improves the efficacy of management at container terminals. As a result, the general speed of global trading would be improved with much less investments. This optimization is done on this particular case, but can be extended to other ports for similar expectations.

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