International Conference on Industrial, Enterprise, and System Engineering
Collaboration of Science, Technology, and Innovation Toward Sustainable Development

Bandung, Indonesia • 16 December 2021

Editors • Nova Indah Saragih, Sheila Amalia Salma, Fitriyana Dewi, Dino Caesaron, Maria Dellarosawati, Dina Rachmawaty, Familia Dwi Winati, Devi Yurisca Bernanda, Fuji Rahayu Wilujeng and Glisina Dwinoor Rembulan
Issues

Select Decade  
2020 🔽

Select Year  
2023 🔽

Issue 6 November - Volume 2693, Issue 1 🔽

PRELIMINARY

Preface: International Conference on Industrial, Enterprise, and System Engineering 🔽

View article  PDF

ICT, SOFTWARE AND HARDWARE ENGINEERING

Performance evaluation of ERP based to ISO/IEC 25010:2011 quality model (a case study) 🔽
Haryasena Panduwiyasa; Yopi Yuda Febrian; Muhardi Saputra; Zalina Fatima Azzahra

Abstract  View article  PDF

Information management for client change requests on the project management and operation in outsourcing company 🔽
Muharan Lubis; Dhuhadmy Anggiya Kirana; Muhammad Dwi Satya; Arif Ridho Lubis

Abstract  View article  PDF

Online voucher e-commerce testing using ISO 9126 model 🔽
Johanes Fernandes Andry; Lydia Liliana; Aziza Chakir; Hendy Tannady

Abstract  View article  PDF

Analysis and prediction supermarket sales with data mining using rapidminer 🔽
Johanes Fernandes Andry; Henny Hartono; Honni; Deny; Jeffrey Jo

Abstract  View article  PDF
Employee’s satisfaction index analysis and prediction using k-means clustering, decision tree, and association rules algorithm

Kevin Christiano; Fendyanto; Devi Yurisca Bernanda; Johannes Fernandes Andry; Francka Sakti Lee

Design of vibration monitoring system and running hour of compressor engine based on internet of things

Priskila Christine Rahayu; Effendi Soewono; Laurentius Geraldi

Application of GPS technology in the design of logistics vehicle monitoring applications

Anggia Dasa Putri; Ellbert Hutabri; Deden Witasyah Jacob

Designing quality metrics for control quality project on educational game development

Fibyan Anthony; Ika Puspita; Wawan Tripiawan

UI/UX evaluation of android-based social media sestyc application with think aloud and heuristic method

Wira Maulana; Sri Rahayu Natasia; M. Gilvy Langgawan Putra

Designing smart applications as a solution for e-service of hydroponics product in the digital era

Rachelia Windi Saputri; Martinus Eko Prasetyo; Yana Erlyana

Designing user interface of Conlab application as a programming learning tool using goal-directed design method

Desita Nur Rosyidiana; Rahmat Fauzi; Ekky Novriza Alam
Garbage classification using convolutional neural network based transfer learning

Faqih Hamami

Analysis of government resource planning relationship in Indonesian government sector for public service

Muhamar Lubis; Rizka Fadhilah; Fritasya Dwiputri Suryoputro

Classification of heart disease trigger factors using Naive Bayes method to predict the risk of heart disease using IoT-based heart rate sensors

Jeffrey Jähnia; Halim Agung; Teady Matius Surya Mulyana; Lukman Hakim; Evaria Sipayung

Forecasting the amount of plywood sales using Holt’s double exponential smoothing

Nico Santosa; Halim Agung; Teady Matius Surya Mulyana; Lukman Hakim; Evaria Sipayung

Determining level of lies with GSR and heart rate parameters using Tsukamoto’s fuzzy logic method

William Steven; Halim Agung; Teady Matius Surya Mulyana; Lukman Hakim; Evaria Sipayung

Implementation of web-based Japanese digital handwriting OCR using chain code and Manhattan distance

Kevin Laurence Hartono; Jusia Amanda Ginting

Improving usability of Telkom university open library website using user-centered design method

Diva Jihan Safira; Alvi Syahrina; Ahmad Musnansyah
Analysis of factors that affect continuance intention on the use of ShopeePay mobile payment using structural equation modeling

Sri Rahayu Nastia; M. Gilvy Langgawan Putra; Aidil Saputra Kirsan; Alya Sekar Ayu Salsabilla

Data integration of SAP business one with website and mobile using AIP (accelerated implementation program) method for configuration

Hanif Fakhurrojo; Muhan Lamaris; Hisyam Ailatat

Analysis of information systems-business strategic planning in vocational high schools

Frisca Febriyani Kurniawan; Berian Maulidya Izzati

Correlation between Twitter sentiment analysis with three kernels using algorithm support vector machine (SVM) governor candidate electability level

Dionisia Bhisetya Rarasati; Josef Cristian Adi Putra

Development of tourism information system for storing tourist visit data and provide tourism information using the scrum method

Ibnu Mas'ud; Sri Rahayu Nastia; Yuyun Tri Wiranti

Service-oriented business collaboration reference architecture: Findings from a systematic literature review

Danniar Reza Firdaus; Maria-Eugenia Iacob; Marten Van Sinderen

MeX FX algorithm in temperature sensor data reconstruction

Shaliuddin Al Fateh; Bimo Sunarfrni Hantono; Agus Bejo
Comparison different supervised learning algorithm to predict crime type (study case: Data of Chicago)
Katia Evelyn Husen; Evawaty Tanuar

Application of winnowing algorithm in development of lecturer research performance information system
Ramadhani Noor Pratama; Effan Najwaini; Abdul Rozaq

Voice-controlled smart home prototype to assist an elder in home care
Handy Wicaksono; Petrus Santoso; Indar Sugiarto; Florenzo Dwipanjung

Application of smart home and smartwatch to assist elders in home care scenario
Handy Wicaksono; Petrus Santoso; Indar Sugiarto; Dwi Kristiyono; Jonathan Aditya Wijaya

Determine of the purchase of ingredient using the apriori algorithm
Herlia Rhomadona; Winda Aprianti; Jaka Permadi

Stock price index prediction using machine learning
Ian L. Perdana; Rofikoh Rokhim

Sentiment analysis of Indonesian society on PPKM Darurat policy based on Twitter data
Lathifah Alfat
INDUSTRIAL AND MANUFACTURING SYSTEM

Location design analysis of distribution centers for medical logistics aid of COVID-19 in West Java

Nova Indah Saragih; Anita Juraida

An order scheduling with the integration of multi mixed-model production line balancing and model sequencing in make-to-order environment: Model development

Ashsyfa Gustina; Yudha Prambudia; M. Deni Akbar

Implementation of the vehicle routing problem concept with heterogeneous fleet and time window to reduce delivery delays at PT. XYZ

Nisri Husna Faadhilah; Muhammad Nashir Ardiansyah; Hardian Kokoh Pambudi
AIP Conf. Proc. 2693, 030003 (2023) https://doi.org/10.1063/5.0136620

Simulation the effect of secondary blade to hammermill machine’s air flow and particle flow

Kevin Gabrianto Rizky Perdana; Agus Kusnayat; Yusuf Nugroho Doyo Yekti
Applying design thinking to identify needs of reminder aids for elderly patients

Nonia Fatima Da Costa Martins; Dino Caesaron; Yusuf Nugroho Yekt

Improvement of 5 kW BLDC electric motor production assembly line for GESITS electric motorcycle at PT. XYZ using genetic algorithm

Abdurrahman Rashif Ibrahim; Dida Diah Damayanti; Ayudita Oktafi

Effect of duration of online classes on student mental workload

Mira Rahayu; Dino Caesaron; Ni Ketut Mega Diana Putri; Annisa Haq; Lukman Nul Hakim

Application of ward’s method and K-means clustering in determining logistics hub locations considering logistics costs

Filsha Nurprihatin; Gilsina Dwinoor Rembulan; Surya Danusaputro Liman

Designing risk register using qualitative methods to electronic package services project

Ryani Amelia; Ika Arum Puspita; Devi Pratami

Interruptions and multitasking in emergency departments: An observational study of the daily work pattern of the doctors

Asyia Mobeen; Muhammad Shafiq; Muhammad Haris Aziz; Muhammad Junaid Mohsin

Digitization of information and technology in manufacturing: A concept evaluation

Tatang Akhmad Taufik; Bernadita Suryawati; Dinar Julietta Istianti; Fairuz Fajri Utomo; Yulia Margiati
Factors affecting female teenagers’ purchase intention towards halal cosmetics

Leni Zahara; Wandhansari Sekar Jatininingrum; Sri Nastiti Andayani Sesanti Retno Utami

Design of proposed improvement of calendering process on cotton carded 24S production at PT XYZ with the DMAI approach

Amira Wisentia Suryandaru; Marina Yustiana Lubis; Yunita Nugrahaini Safrudin

Potential for increasing value captured in java furniture company (JFC)

Moses Laksono Singgih; Safira Fortuna Aji; Dewanti Anggrahini

Fuzzy-based decision making model for component repair using additive manufacturing

Siti Syahara Mad Yusoh; Dzuraidah Abd Wahab; Abdul Hadi Azman

Prevalence of the willingness to receive COVID-19 vaccine among nurses in Indonesia

Sheila Amalia Salma; Tiara Verita Yastica

Effect of movement speed and flow capacity on the printed chocolate in 3D printing machine

Reza Mahardika; Muhammad Musthofa; Rafiq Aly Nurdin; Setyawan Bekti Wibowo

A simulation of berth scheduling problem for container terminals considering internal trucks and vessels arrival time

Maulin Masito Putri; Muhammad Faisal Ibrahim; Riki Ratih Triwardani
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>DOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental workload analysis in PPIC division using NASA-TLX method at PT ABC</td>
<td>Atyanti Dyah Prabaswari; Fahri Danianto; Bagus Wahyu Utomo</td>
<td><a href="https://doi.org/10.1063/5.0119378">https://doi.org/10.1063/5.0119378</a></td>
</tr>
<tr>
<td>Design of post-Covid 19 sustainability of coffee agroindustry supply chain in Indonesia</td>
<td>Iphov Kumala Sriwana; Praty Poeri Suryadhidhi; Wawan Triawwan; Ulfia Eka Khapso</td>
<td><a href="https://doi.org/10.1063/5.0119126">https://doi.org/10.1063/5.0119126</a></td>
</tr>
<tr>
<td>Improving the quality of production of power transformer tank using six sigma approach in tank fabrication</td>
<td>Nur Aswan Darwis; Moses Laksono Singgih</td>
<td><a href="https://doi.org/10.1063/5.0174460">https://doi.org/10.1063/5.0174460</a></td>
</tr>
<tr>
<td>Discrete cuckoo search algorithm in scheduling dynamic route of medical and non-medical waste transportation at regional-based health facilities during the Covid-19 pandemic</td>
<td>Miftahol Arfin; Syarif Hidaytulloh; Sarah Karenina Sari</td>
<td><a href="https://doi.org/10.1063/5.0118767">https://doi.org/10.1063/5.0118767</a></td>
</tr>
<tr>
<td>Exploring the concurrent impact of costs, travel time and CO2 Emissions within a hybrid aisle-line warehouse through genetic algorithm</td>
<td>Marialuisa Menanno; Matteo Savino</td>
<td><a href="https://doi.org/10.1063/5.0119162">https://doi.org/10.1063/5.0119162</a></td>
</tr>
<tr>
<td>Model development of capacity and production planning in the supply chain of coconut oil agroindustry</td>
<td>Melizar</td>
<td><a href="https://doi.org/10.1063/5.0119082">https://doi.org/10.1063/5.0119082</a></td>
</tr>
<tr>
<td>Sustainable supplier selection and order allocation: A systematic literature review</td>
<td>Alina Cynthia Dowi; T. Y. M. Zagloei</td>
<td><a href="https://doi.org/10.1063/5.0121000">https://doi.org/10.1063/5.0121000</a></td>
</tr>
</tbody>
</table>
Feasibility analysis of 5G mmwave planning: Profit, risk, and investment

Alfin Hikmaturokhman; Kalamullah Ramli; Muhammad Suryanegara; Dina Rachmawaty

RULA-based work posture evaluation for Indonesian workers: A comparison between office and manufacturing

Rio Prasetyo Lukodono; Chiuhsiang Joe Lin

Overview of ergonomics implementation in small medium enterprises industries in the home industry-based food business

Kukuh Lukiyanto; Anang Ramadhan Feri Pratama

Integration of quality function deployment (QFD) and analytical hierarchy process (AHP) to improve student information system

Familia Dwil Winati; Dina Rachmawaty; Achmad Zaki Yamani; Hawwin Mardhiana

Text mining implementation in complaint management: A case study at Surabaya city office for population administration and civil registration (COPACR)

Maria Anitasari; Irmanda Dwi Ayu Indriasari

Job shop production layout optimization using combined CORELAP and CRAFT algorithms

Belachew Mebrat; Bereket Haile
AIP Conf. Proc. 2693, 030031 (2023) https://doi.org/10.1063/5.0118878

Measurement of logistics service quality among courier service in Banyumas Regency using an importance performance analysis (IPA) approach

Nabila Noor Qisthani; Achmad Zaki Yamani
Workers energy expenditure relationship with room temperature and brightness in product packing area

Teguh Oktiarso; Eudyia Kurniandyani; Purnomo

Enhancing the cluster-first route-second approach for equitable distribution through logistics hubs determination

Glisina Dwinoor Rembulan; Filscha Nurprihatin

INNOVATION IN INTEGRATED ENGINEERING

Designing project management office with supportive model at Bandung Techno Park

Ariefyarto Taufiq Ramadhan; Devi Pratami; G. N. Sandhy Widyasthana

A business model design of CV. Kayakayu Jepara using business model canvas with qualitative judgment

Muhammad Rafiendra Khair; Sinta Aryani; Maria Dellarosawati Idawicaksakti

Designing risk response using qualitative risk analysis for copper to fiber optic migration project

Raisya Fadhilla Dzafarani; Devi Pratami; Putu Yasa

The changing of government's interaction due Covid-19 pandemic: A comparative study about technology use in Malaysia and Indonesia
Designing of client module on Pahamee’s website about mental health using extreme programming method

Riri Anisa Arisdila; Warih Puspitasari; Alvi Syahrina


Reviving Indonesian Panji Tales in modern fashion product design with augmented reality

Christabel Parung; Markus Hartono; Wyna Herdiana; Prayogo Waluyo; Guguh Sujatmiko; Brian Kurniawan Jaya


Defining the key factors of industry 4.0 adoption in the manufacturing industry: A systematic literature review

Meriastuti Ginting; T. Y. M. Zagbel


MANUFACTURING AND MATERIALS ENGINEERING

Supply chain performance measurement for manufacturing industry: A study during pandemic (Covid-19)

Ferdoush Saleheen; Md. Mamun Habib


Design and control of high voltage gain transformerless DC-DC converter

M. Aldy Wildan Maulana; Misbahul Munir; Irham Fadlika; Arif Nur Afandi; Taufik

A simulation of berth scheduling problem for container terminals considering internal trucks and vessels arrival time

Maulin Masyito Putri; Muhammad Faisal Ibrahim; Rifki Ratih Triwardani

AIP Conf. Proc. 2693, 030018 (2023)
https://doi.org/10.1063/5.0118770
A Simulation of Berth Scheduling Problem for Container Terminals Considering Internal Trucks and Vessels Arrival Time

Maulin Masyito Putri\textsuperscript{1,a}, Muhammad Faisal Ibrahim\textsuperscript{1,b}, and Rifki Ratih Triwardani\textsuperscript{1,c}

\textsuperscript{1}Department of Logistics Engineering Departement, Universitas Internasional Semen Indonesia, PT. Semen Indonesia (Persero) Tbk. Area, Jl. Veteran, Sidokumpul, Gresik, Jawa Timur 61122, Indonesia

\textsuperscript{a}) Corresponding author: maulin.putri@uisi.ac.id
\textsuperscript{b}) Muhammad.ibrahim@uisi.ac.id
\textsuperscript{c}) rifki.triwardani16@student.uisi.ac.id

Abstract. This research develops a berth scheduling simulation model to solve the Berth Scheduling Problem at a container terminal. Berth scheduling is influenced by the vessel's arrival time, because it will affect the availability of the quay and material handling. The vessel needs material handling for loading and unloading process in container terminal, there are quay cranes and internal trucks. The internal truck moves the unloading containers from quay to the container yard and the loading containers from container yard to the quay. When the loading and unloading process of a vessel is running, an internal truck is dedicated to a quay crane until the loading and unloading process of a vessel is complete. The number of quay cranes serving a vessel is determined based on the LOA (length over all) of vessel. The quay crane will start loading and unloading when the internal trucks arrive at the quay. It often causes the quay cranes and vessels to wait for loading unloading process. In addition, this will have an impact on the berthing time of the vessel and the waiting time for other vessels that will berth. This research develops a berth scheduling simulation by considering the arrival time of the vessels and internal trucks to get the vessel's berthing schedule and assign the quay crane by minimizing waiting time and berthing time.

INTRODUCTION

In recent years, there has been an increase in the number of containers in all Indonesia’s container ports. In 2019, it was recorded that 14.7 million TEUs of containers were served by Indonesia’s container port, an increase of 4.79% from 2018 [1]. It's supported by the government policies for developing Indonesia's maritime infrastructure and business processes. These policies are expected to minimize dwelling time or to minimize the length of time ships are docked for loading and unloading to increase container port service capacity. To achieve this goal, it is necessary to have operational efficiency for Indonesia's container port services.

There are five important parts in the operation of a container port, they are gate, container yard (CY) or storage yard (SY), transport, dock (quay) and berth as described in Fig. 1. [2]. Gate is the entrance and exit of customer trucks to or from CY and dock. CY is a temporary storage for containers to be loaded or unloaded to or from the vessel. Transport is a truck or material handling equipment such as an Automated Guide Vehicle (AGV), internal trucks, forklifts, etc. In this area, there is stacking crane equipment that can receive / deliver vehicles from / to trucks and vehicles to the quay. Stacking cranes also carry containers in CY. The dock is the place for loading and unloading ships with a quay crane (QC) tool. QC unloads the unloading container (domestics or international
containers) and loads them on the internal trucks for transferring the containers to CY. And the berth area is a pool adjacent to the quay and is used to dock the vessels.

In the quay area, there is process for loading and unloading containers to and from the vessel and process for loading and unloading containers from and to internal trucks (transport). The loading unloading process is assisted by one or more QC for each ship. QC will work when the ship is ready to be unloaded or loaded and the truck is ready in loading and unloading position. The process of loading and unloading vessels is carried out in accordance with the availability of the quay and material handling. To minimize accidents, some Indonesia's container ports only allow internal trucks (port-owned trucks) that are allowed to enter the port area and to avoid queuing for trucks at the quay area. The ship's arrival schedule will affect the number of QC that will be used to serve each ship and the number of internal trucks that will serve each QC on each ship.

There are some previous studies related to berth allocation and scheduling. Some research integrating berth allocation and QC assignment and scheduling (BACAP & BACASP) [3] [4] [5] [6]. Turkogullari, et al. develop the BACAP models use linear programming model with integer 0-1, and the BACASP models use linear programming with mixed integers [3]. They have developed the BACASP model from previous studies which only cover 15 ships to 60 ships [3]. Correcher, et al proposes the metaheuristics approach based on Biased Random-key Genetic Algorithm with memeptic characteristics and several Local Search procedures in BACAP and BACASP [4]. That approach can find the optimal solutions for up to 100 ships in an instance [4]. Malekahmadi, et al present an integer programming model for BACASP [5]. They use random topology particle swarm optimization algorithm (RTPSO) to solve BACASP at the large-size instances [5]. Han, et al use a mixed integer programming model and simulation based Genetic Algorithm (GA) search procedures to solve the BACASP [6]. They address berth and quay crane problems in a simultaneous way, with some uncertainty in time, like vessel arrival time and container handling time [6]. Arango, et al focus on BACASP and yard allocation problems to minimize the total service time or operating time [7]. They use optimization model to solve the problem and develop a genetic algorithm to solve the mixed integer model under three different situations in a Spanish Port [7].

Hammad, et al have compared 3 models of berth Allocation Problem (BAP), namely dynamic and discrete berth allocation problem model (DDBAP), dynamic and continuous berth allocation problem model (DCBAP), and dynamic and hybrid berth allocation problem model (DHBAP) to find out which models can be used as a standard model for all type of terminal layouts and gives most satisfactory results at the level of minimization of ships turnaround time in the port [8]. By using CPLEX, Himmaouti, et al (2020) can find out that DHBAP is the best model that is qualified to be applied in all types of terminal layouts [8].

This research will simulate the berth scheduling to determine to minimize the waiting time and the berthing time of vessels. This study determines the berthing location of vessels based on the vessel’s arrival time and the availability of QC and determines the optimal number of internal trucks.

**PROBLEM DEFINITION**

There are ten QC on the quay for loading unloading containers from or to ship. There are 5 units QC on the international quay and five units on the domestic quay. The distance between QC is 100 m. The LOA (length over all) of the ship determines the number of QCs serving the ship. The ship with LOA less than or equal to 225 meters (LOA≤225) are served by one QC, while ships with LOA more than 225 meters (LOA>225) are served by 2 QC. There are two types of containers, loading container and unloading container. After the ship has docked at the quay, the QC unloads the unloading containers and transferring them to the internal truck for transfer and storage at CY. After all the unloading containers have been moved to CY, the internal truck carries the loading containers from CY to QC to be loaded to the ship. The quay layout is described in Fig. 2 and the distance matrix between QC, CY and garage is shown in Table 1. The port manages trucks with dedicated dispatching strategy to QC. One QC is served by seven trucks and a truck will be assigned to a QC until finish serve a ship. The starting point of the trucks is garage. When the truck is finished serving the ship will return to the garage. The speed of internal trucks is constant 20 km/h.
FIGURE 1. Container Terminal Layout

TABLE 1. Distance Matrix (Meter)

<table>
<thead>
<tr>
<th>To</th>
<th>CY I1</th>
<th>CY I2</th>
<th>CY I3</th>
<th>CY I4</th>
<th>CY I5</th>
<th>CY D1</th>
<th>CY D2</th>
<th>CY D3</th>
<th>CY D4</th>
<th>CY D5</th>
<th>Garage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>1755</td>
<td>1830</td>
<td>1905</td>
<td>1980</td>
<td>2055</td>
<td>2130</td>
<td>2205</td>
<td>2280</td>
<td>2355</td>
<td>2430</td>
<td>1725</td>
</tr>
<tr>
<td>I2</td>
<td>1605</td>
<td>1680</td>
<td>1755</td>
<td>1830</td>
<td>1905</td>
<td>1980</td>
<td>2055</td>
<td>2130</td>
<td>2205</td>
<td>2280</td>
<td>1575</td>
</tr>
<tr>
<td>I3</td>
<td>1455</td>
<td>1530</td>
<td>1605</td>
<td>1680</td>
<td>1755</td>
<td>1830</td>
<td>1905</td>
<td>1980</td>
<td>2055</td>
<td>2130</td>
<td>1425</td>
</tr>
<tr>
<td>I4</td>
<td>1305</td>
<td>1380</td>
<td>1455</td>
<td>1530</td>
<td>1605</td>
<td>1680</td>
<td>1755</td>
<td>1830</td>
<td>1905</td>
<td>1980</td>
<td>1275</td>
</tr>
<tr>
<td>I5</td>
<td>1155</td>
<td>1230</td>
<td>1305</td>
<td>1380</td>
<td>1455</td>
<td>1530</td>
<td>1605</td>
<td>1680</td>
<td>1755</td>
<td>1830</td>
<td>1125</td>
</tr>
<tr>
<td>D1</td>
<td>1990</td>
<td>2065</td>
<td>2140</td>
<td>2215</td>
<td>2290</td>
<td>2365</td>
<td>2440</td>
<td>2515</td>
<td>2590</td>
<td>2665</td>
<td>1625</td>
</tr>
<tr>
<td>D2</td>
<td>1865</td>
<td>1940</td>
<td>2015</td>
<td>2090</td>
<td>2165</td>
<td>2240</td>
<td>2315</td>
<td>2390</td>
<td>2465</td>
<td>2540</td>
<td>1500</td>
</tr>
<tr>
<td>D3</td>
<td>1740</td>
<td>1815</td>
<td>1890</td>
<td>1965</td>
<td>2040</td>
<td>2115</td>
<td>2190</td>
<td>2265</td>
<td>2340</td>
<td>2415</td>
<td>1375</td>
</tr>
<tr>
<td>D4</td>
<td>1615</td>
<td>1690</td>
<td>1765</td>
<td>1840</td>
<td>1915</td>
<td>1990</td>
<td>2065</td>
<td>2140</td>
<td>2215</td>
<td>2290</td>
<td>1250</td>
</tr>
<tr>
<td>D5</td>
<td>1490</td>
<td>1565</td>
<td>1640</td>
<td>1715</td>
<td>1790</td>
<td>1865</td>
<td>1940</td>
<td>2015</td>
<td>2090</td>
<td>2165</td>
<td>1125</td>
</tr>
<tr>
<td>Garage</td>
<td>175</td>
<td>250</td>
<td>325</td>
<td>400</td>
<td>475</td>
<td>550</td>
<td>625</td>
<td>700</td>
<td>775</td>
<td>850</td>
<td>0</td>
</tr>
</tbody>
</table>

MODEL

Conceptual Model

The conceptual model of this research is described in the Activity Cycle Diagram (ACD) as in Fig. 3. ACD describes the sequence of processes that occur during the loading and unloading process of containers. When the vessel arrives, the vessel will wait to determine which quay area and QC will serve the vessel. After that, the vessel will berth at the quay and setup the loading and unloading process. Furthermore, the containers will be unloaded using QC and request the internal trucks from the garage to move to the QC. The containers will be loaded by internal trucks and transferred to CY. The containers to be unloaded are then stacked by CY's crane in CY. If there are still unloading containers on board, the internal trucks will immediately return to QC. If there are not unloading containers on vessel, the truck will load at CY and deliver the containers to QC to be loaded on the vessel. When all the loading containers have been loaded on the vessel, the internal truck will return to the garage and the vessel is ready to take off the berth.
Simulation Model

The simulation model consists of two sub-models, there are the quay sub-model (Fig. 4) and the CY sub-model (Fig. 5). The quay sub-model simulates the ships and the internal trucks arrival, the vessels berthing process, the loading and unloading process of QC, the loading and unloading process of internal trucks and the movement of internal trucks to CY. Meanwhile, the CY sub-model simulates the arrival of internal trucks from the quay area, the loading and unloading process of internal trucks and ASC and the movement of internal trucks to the quay area.

When the internal truck is idle, the internal truck will go to the garage to wait for the assignment. If there is an unloading assignment at the quay area, then the truck will go to the quay area from the garage. If there is an unloading assignment at CY, the internal truck will go to CY from the garage.
After doing simulation modeling and running simulations, the next step is to determine the number of running replications. Running the simulation once, may not necessarily produce a value that is representative of the real system. In this replication process, it is done by trying to simulate with 10 replications for the initial replication and calculating the estimated population average interval (half-width) based on the simulation replication sample. From initial replication, the standard deviation is 2908.9. With $\alpha=0.05$ and $\left( t_{\frac{1-\alpha}{2}} \right) = 2.2622$, so the half-width ($hw$) value is:

$$ hw = \frac{\left( t_{\frac{1-\alpha}{2}} \right) s}{\sqrt{n}} \quad (1) $$

$$ hw = \frac{2.26 \times 2909.9}{\sqrt{10}} = 2081.67 $$

With $\alpha=0.05$ and $z_{\frac{\alpha}{2}} = 1.96$, so the number of replications is:

$$ n' = \left[ \frac{z_{\frac{\alpha}{2}} \times s}{\beta} \right]^2 \quad (2) $$

$$ n' = \left[ \frac{1.96 \times 2909.9}{2081.67} \right]^2 = 7.507 \approx 8 $$

To ensure that the simulation model represents the conceptual model, verification and validation process of the simulation model is carried out. Verification of the simulation model is done by testing the model and making sure there are no errors. In this research, verification process was carried out with the "check model" menu on the simulation software to see if there were errors. From the verification process results obtained the results of "No Error or Warning in Model". Based on these results, it can be concluded that the simulation model is verified and there are no errors in the simulation model. Then, the simulation model validation process is carried out using the student’s-t test statistical method with confidence interval 95% on the number of loading and unloading containers to the vessel. The student’s-t test aims to compare the simulation results statistically, there is no significant difference with the existing conditions. The result of student’s-t test is described in Table 2 and Table 3. Based on Table 3 and Table 4, all student-t test results show that the t-count value is in the range of t-table values (t critical two-tail), then the result is accepting H0 or there is no significant difference between the simulation results and the existing conditions. So, the simulation model has been validated.
TABLE 2. The Student’s-t Test Result For The Number of Loading Containers

<table>
<thead>
<tr>
<th>t-Test: Two-Sample Assuming Unequal Variances</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>255.8</td>
<td>257.6</td>
</tr>
<tr>
<td>Variance</td>
<td>27084.56812</td>
<td>16454.9101</td>
</tr>
<tr>
<td>Observations</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Df</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-0.07217386</td>
<td>VALID</td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.471287236</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.656659413</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.942574472</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>1.978380405</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 3. The Student’s-t Test Result For The Number of Unloading Containers

<table>
<thead>
<tr>
<th>t-Test: Two-Sample Assuming Unequal Variances</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>202.8</td>
<td>198.371429</td>
</tr>
<tr>
<td>Variance</td>
<td>40778.88696</td>
<td>18028.0919</td>
</tr>
<tr>
<td>Observations</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>0.152791164</td>
<td>VALID</td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.439409791</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.657650899</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.878819583</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>1.979930405</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

We simulate six vessels with seven working days. The berth scheduling with the allocation QC described in Fig. 4, while the simulation result described in Table 2. The vessel berth directly when arrived port. The first vessel docked immediately when it arrives in container terminal area. It's because all QC and internal trucks are available. When the vessel docked, seven internal trucks from the garage headed to QC D1. When one internal truck arrives at the loading location, the QC unloads the container and loads it to the internal truck. Then the internal truck will move to CY and the second arrival internal truck will occupy the loading position to carry out the process like the previous truck.
FIGURE 4. Berth Scheduling

<table>
<thead>
<tr>
<th>Ship ID</th>
<th>ATQ</th>
<th>QC ID</th>
<th>Internal Truck ID</th>
<th>Departure Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>HISA031</td>
<td>11/29/2019 18:06</td>
<td>QC D1</td>
<td>T1 T2 T3 T4 T5 T6 T7</td>
<td>12/3/2019 3:24</td>
</tr>
<tr>
<td>SEGA049</td>
<td>11/30/2019 8:56</td>
<td>QC D2</td>
<td>T8 T9 T10 T11 T12 T13 T14</td>
<td>12/4/2019 6:10</td>
</tr>
<tr>
<td>SITU055</td>
<td>12/2/2019 13:00</td>
<td>QC D3</td>
<td>T29 T30 T31 T32 T33 T34 T35</td>
<td>12/5/2019 23:00</td>
</tr>
<tr>
<td>DERA043</td>
<td>12/2/2019 15:12</td>
<td>QC D4</td>
<td>T36 T37 T38 T39 T40 T41 T42</td>
<td>12/3/2019 0:12</td>
</tr>
</tbody>
</table>

The container terminal needs 4 QC in domestic dock and 2 QC in international dock for serving 4 domestic ships and 2 international vessels. With dedicated dispatching strategy (7 internal trucks for 1 QC), the container terminal needs 42 internal trucks.

<table>
<thead>
<tr>
<th>Ship ID</th>
<th>QC</th>
<th>Internal Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>HISA031</td>
<td>207.925</td>
<td>0.180</td>
</tr>
<tr>
<td>SEGA049</td>
<td>232.225</td>
<td>0.176</td>
</tr>
<tr>
<td>TRAT004</td>
<td>12.790</td>
<td>0.039</td>
</tr>
<tr>
<td>OSTO002</td>
<td>22.605</td>
<td>0.076</td>
</tr>
<tr>
<td>SITU055</td>
<td>109.195</td>
<td>0.090</td>
</tr>
<tr>
<td>DERA043</td>
<td>15.590</td>
<td>0.092</td>
</tr>
</tbody>
</table>

From Table 5, we can analyze that by adding the number of QC assigned to a ship, it will speed up the loading and unloading process on the ship. So, we can minimize the waiting time of QC and the waiting time of internal truck in QC and in CY. And the most important is the container terminal can minimize the berthing time of ship and increase their utility with serve more ship. Internal truck dedicated dispatching strategy also affects to the waiting time of QC.

CONCLUSION

Based on the research results, it can be concluded that berth scheduling by considering the arrival time of vessel and internal truck can minimize QC waiting time or idle time and internal truck waiting time. So, they can minimize the berthing time and increase their utility with serve more vessel. In addition, we can use this simulation to evaluate internal truck dispatching strategies by increasing or decreasing the number of internal trucks per QC with a little bit model development. From the research results, it is known that 7 internal trucks result in high total waiting time. So, it is necessary to have a strategy to increase the number of internal trucks to serve QC. For further research, it is necessary to consider the route of the internal truck to minimize travel time and the container yard template.
ACKNOWLEDGMENTS

The authors would like to say thanks to the reviewers for any suggestions to improve the quality of this paper and Community Service of Universitas Internasional Semen Indonesia for the financial support of this study.

REFERENCES