Optimization of the Storage Sites for Export, Inbound and Reorganize Containers by Timing Location

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Abstract: Today, seaports subtend an increasing growth of containers stacking. Countries are striving to get the most benefit from it and increase their share of this sector's resources, as well as optimizing their competitiveness. Despite this increase, the ports suffer from many problems, including how to take the appropriate decision to store and empty containers of various kinds. In this paper, we propose a method for storing containers at (El Qasr El Saghir) terminal in Morocco, based on the hypothesis of time dynamics for choosing the optimal location for the container in the yard. This hypothesis provides ideal storage locations for containers arranged by time to avoid the accumulation of containers, reduce the forced movement of previously stored containers. As well as facilitate the decision to relocate containers stored in the terminal to allow the provision of new storage places, reducing time and operating cost. We propose to apply artificial intelligence (particularly ANN) to this methodology (a case study on El Qasr El Saghir); for example, deciding for stacking containers with different departure dates; because the parameters of our methodology are compatible with the ANN algorithm.

1 INTRODUCTION

Without the ports, countries remain isolated from the world. With it, communication horizons are opened, the economy is strengthened and policies remain independent, as it is one of the most important sectors that support all industries, productive sectors, sustain all sectors of the national economy which contributes to promoting foreign trade and increasing investments. Container terminals increase their competitiveness and here it is clear that container terminals face increasing pressure to maintain quality of service to increase container productivity. The increasing competition to improve efficiency at container terminals has attracted the attention of process analysts. According to (Stahlbock & Voß, 2007), (Murty et al., 2005) (Vis & de Koster, 2003), overviews of operations and process problems at container terminals and references on methods for solving problems of these processes. In this paper, we examine one of these important operational problems: allocating storage locations for inbound containers, export, and reshuffles.

According to (Salebeh, T. & Debo, A., 2020) the storage yard of the container terminal is divided into large storage areas called blocks. Figure 1 shows a typical storage block in a station. Usually, these containers are either outbound or inbound. Each type has different characteristics (e.g., type, arrival time/date, departure time/date, weight). Containers of different sizes arrive through ships and are loaded onto external trucks or trains called incoming containers and on the other hand, export containers are brought by trucks or other means of transport to be loaded onto ships where the time of arrival of the means of transport is unknown compared to the time of arrival and departure of ships (Murty et al., 2005), (Zhang et al., 2003).

The slot is the smallest storage unit in the location for one container, where the container in this storage

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position is naturally located with its longest side either on the floor or precisely on another container (of the same size). Containers are stacked one on top of the other to form a column and the pillars are placed together by the longest of them side by side to form a bay.

The block is formed by placing many bays together so that the container's doors are in one direction at the front and the end in the other direction. The locations of the same level in a block form a tier. Columns that stack next to each other in the block form a bay.

Joining two bays together in the block constitute the Paired-Bay. In general, ternary (row, tire, bay) specifies (r, t, b) coordinates of the (container) location in the block. The length of the block is determined based on the number of bays grouped by the design of the storage yard and it is usually approximately 20. The width (the number of rows) and height (the number of tiers) of the block are determined by the type of yard cranes used in the block. The most common type of yard cranes, Rubber Tire Gantry Cranes (RTGC), generally have a bridge spanning six bays of containers stacked from four to five levels high.

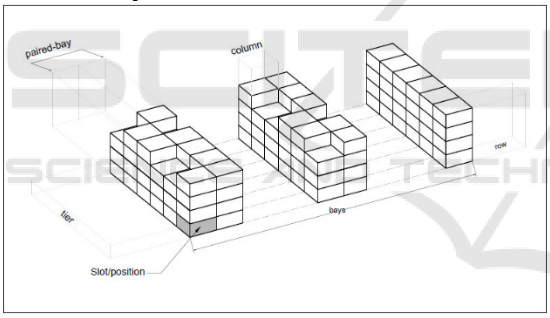

Figure 1: A container - Storage Paired-Bay in block

Railroad Structures Fixed Quay Cranes (RMGC), which are larger than its predecessor, as it extends over 13 rows of containers stacked at six heights and there are other types of yard cranes, of different widths and heights, for stacking (Salebeh, T. & Debo, A., 2020).

Furthermore, we found in literary studies that some container terminals adopt different storage methods that meet their need. The large container terminals have separate storage areas for export and import containers and temporary areas designated for containers that have just been emptied from or loaded onto ships. Sometimes the export and import containers are mixed into blocks, sometimes even in bays. The adoption of these methods forces the station to rearrange mixed containers based on species distinction and the reorganization of future retrieval operations. This increases the cost, time, effort of the cranes; there is no doubt that this reduces the productivity and competitiveness of the terminal. This process (rearrangement) requires informed and appropriate decision-making as it affects the efficiency of the container yard's productivity (Kim & Park, 2003). (Cobo, 2018) Present a general dynamic pattern of container arrival and expected handling effort for storage yard equipment by proposing a methodology for allocating space for outbound container storage and one place for each outbound container.

According to (Voß et al., 2004), in the first part, sites in the yard are reserved before the ship's arrival and then the containers are grouped, the weight principle is adopted between the lighter and then heavier containers to ensure the stability of the vessel. In the second part, some terminals use online procedures that do not require a pre-booking reservation of space and that adopt scattered planning. When a new container arrives, the berthing location of the vessel is determined and then a good location for the container is located in the specified space in real-time, according to the category.

According to (Zhang et al., 2003) presented his study on two levels; the first level worked to reduce berthing by merging the work of the (Quayside Crane) and storage yard cranes (RTGs) to scatter containers between different blocks, whether outgoing or incoming. The second level provides a detailed solution to reduce the outbound container transport distance between the block in the storage space (block) and the ship's berthing place. In this paper, we study in detail the problem of allocating storage locations to determine the optimal location for the container storage in the terminal yard.

According to known stowage schemes for ships and container handling sequence, the problem of optimized site allocation arises when import/export containers arrive; these site allocation decisions are made continuously in real-time as inbound/outbound containers arrive and depart. This paper shows the sequence of handling container storage according to the characteristics referred to in the information of arrival containers (Figure 3).

This method can deal with the problem of container's locations in blocks, especially in bays, because it enough to solve the problem of allocating a site for the container in the block, allocating the site in the bay and therefore the best slot in the bay is the best slot for the entire block in the terminal. If the activities in the storage yard are not properly coordinated, ill-advised and costly rearrangements are carried out and cause traffic congestion from the carriers. Indeed this one-stack problem is very complex (Avriel et al., 2000). Hence it is only natural that studying the detailed site allocation problems of a single stack is ineffective in the block.

In this approach, we first present a two-part methodology of bay-timing. The first is the allocation of double bays in the block and the second part addresses the problem of allocating ideal sites for storing containers. In general; the methodology divides the blocks into Paired-Bays, in which the incoming, outgoing, and refrigerated containers are stored with taking into account the characteristics of each type. The methodology is mainly based on the exact time for each container location, which gives the Paired-Bay the time mechanism. Then we determine the ideal location for the container by the previous content of the bays with the inclusion of the variables related to the bay and the containers (Figure. 3). The methodology and its flexibility are discussed in the section (Methodology).

Sharing, analyzing, and utilizing operational data in real-time is essential, so we need the best ways to use it; applying artificial intelligence is a perfect solution for processing the big data generated by this method or similar methods. Dealing with the huge amount of data resulting from this problem is a challenge in itself, in addition to making appropriate and well-informed decisions. Undoubtedly, applying artificial intelligence techniques to analyze this data will be a much more intuitive and effective method than any traditional method can do. The rest of the paper is structured as follows: Section 2 presents the methodology and scenarios. Section 3 presents Artificial Intelligence. Finally, Section 4 concludes the study.

2 THE METHODOLOGY OF BAY-TIMING

When a ship arrives, the person responsible for managing the terminal has information about the containers (number, type, time/date of the arrival, time/date of the departure, etc); he will allocate places for these containers in a way that does not affect the departure of the previous containers. This issue raised an important question: How does one know what is the date and time of receiving a container and how can we reduce the time, cost, and operational effort? Looking for an answer to this question ensures that the container is not buried in the depths of the piles when it is time to leave the yard, which reduces the number of operations required to reach the container in question. We propose the methodology of "Bay-Timing"; It is a methodology for managing locations within a block, which operates the location inside bays according to time, specifically chronic two bays in one block. This study demands that the container's location in the storage yard be arranged according to the departure time as if each slot of the container is defined by date-time and therefore the processing of containers storage begins according to the containers with the farthest time range.

First, we formulate the following definitions:

Paired-Bay: is the even division of bays in a single block.

Chronic-Bay: is a suggested method for linking the bay with a specific date-time based on the time range of the containers that are stored in the bay so that maintains the arrangement of storage and disbursing and also rearranging the containers.

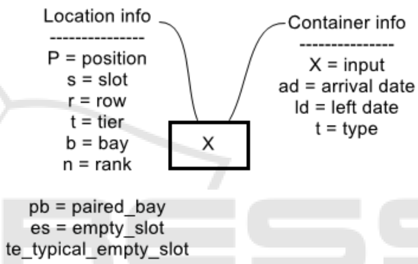

Figure 2: Attributes used in the methodology

Reserved Bay: is a Paired-Bay that is reserved in each block with the aim of flexibility to re-store the containers in exceptional cases that do not comply with the methodological standards for storage, such as the one that expired the period allowed in the bay designated for storage in the terminal yard and the storage in it is processed on an individual basis.

The Paired-Bay reservation methodology provides the ease and flexibility of storing a batch of containers with different dates (known or unknown); this is what we will try to clarify through this section; the Paired-Bay methodology divides a block consisting of six rows, four layers, eight bays (four Paired-Bays (8/2 = 4). So, one block capacity = 6 * 4 * 8 = 192 locations. Figure 3. shows only one row with four tiers in the length of four Paired-Bay.

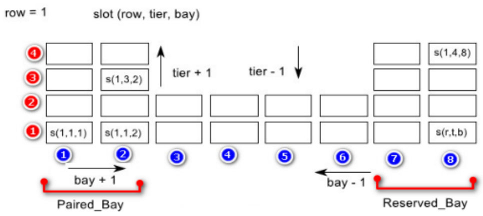

Figure 3: Paired-Bay in the block

In general, for each location, whether vacant or full, there is a row number, tire number, and bay number, and this location is denoted by the symbol (P). We present the following notation that used in the Paired-Bay methodology (Figure 3.):

N: the total number of slots. **n**: the rank of slots.
X: the Input(the container).
s: slot, **r**: row, **t**: tier, **b**: bay, **pb**: Paired-Bay,
Pe: Position_empty (vacancy slot)
fs: full_slot, **tes**: typical_empty_slot
ad: arrival_date, **ld** : left_date, **t**: container_type.
tg: time group of arrival container(probability variable).
tc (Cz): the input(container) that located under the empty_slot (the element of decision for stocking)
Pr: the probability of the time group.
Pr(ad)(tg): the probability of the time group of the arrival container(tg) with arrival date(ad).
Pr(ld)(tc): the probability of the already storage container(tc) with the left date(ld).

See Figure: 4. which represents the configuration of the Paired-Bay method. We will process the situation as in real-time, so we have 48 slots, 29 slots are full, and 19 slots are empty (6 * 4 = 24 slots in every bay, 48 in every Paired-Bay), we will illustrate three scenarios based on Figure: 4.

The objective function which selects a location of an arrival container and minimizes the total expected number of relocation movements can be formulated as follows:

$$f(x) = \begin{cases} Pe(r+1,t,b), tg(ld) > tc(ld) \\ Pe(r,t,b), \quad tg(ld) \le tc(ld) \end{cases} \quad (1)$$

$$\sum_{b=1}^{B} .. \sum_{t=1}^{T} .. \sum_{r=1}^{R} tg \quad (n, ad, ld, t)(Pe(r,t,b)) \quad (2)$$

2.1 Scenarios

For illustration, we assume one Paired-Bay of six rows and four tires at most, as shown in Figure: 4. There are 24 locations in the one bay and 48 locations in the Paired-Bay, each location represented by a square. In (Bay A), the reserved locations are 15 and 14 locations in (Bay B), vacant locations display empty squares. The containers are stored in chronological order according to the time dimension rule (Farest date is First In) and in the export according to the (Earliest Date First Out). The numbers represent their distinct chronological order in the squares. This method constitutes a flexible construction for dynamic storage and container retrieval; the presence of prior storage means that there is a given configuration of the block, even if partially, so storing containers based on time implies that the retrieval sequence process will be well defined and this, in turn, affects many aspects.

Paired-Bay in date (25-01)

Bay a

t4			27	29		
t3	3		28	29		
t2	3		28	29	27	
t1	3	1	29	29	27	24
t/r	r1	r2	r3	r4	r5	r6

24 (slots) – 15 (Pfs) = 9 (Pes)

Bay b

t4					26	
t3	4			30	26	
t2	5		25	30	26	
t1	6	2	25	30	26	20
t/r	r1	r2	r3	r4	r5	r6

24 (slots) – 14 (Pfs) = 10 (Pes)

Figure 4: Empty and full slots in the Paired-Bay

Including reshuffling containers if required. So in this Paired-Bay, we will have 19 empty spaces ready to receive the new batch of containers. There are several scenarios in which the method of the store, departure, and rearrange/reshuffle will be represented according to our methodology.

2.1.1 Scenario 1 (5 Containers Arrive with the Unknown Departure Date)

Assuming the configuration shown in Figure 4. specified on (25-Jan) and five new containers are arrived on (27-Jan), but the date of departure is unknown, so they are stored based on the permissible period of stay of containers in the yard It is from (4 - 7 days) and also can be adapted according to the laws in force at the station.

In (Bay a), we have container one on location (r2, t1, Ba) being reshuffled on top of container three on location Pe(r1, t4, Ba), in this case, this change provides (4 locations) vacant to store containers (with the same date), so that the permissible period (for these containers whose departure date is unknown) does not exceed the yard (max date) and do not store the unknown departure date containers on top of containers have a known departure date, after this process the (Bay a) considered full, noting that the remaining vacancies in the (Bay a) It cannot be stored because the containers under these vacant places have a known departure date and we cannot put containers on top of them whose departure date is unknown.

In (Bay b), we will have the same condition that container 2 in position (r2, t1, Bb) will be reshuffled to location Pe(r1, t4, Bb) over the site (r1, t3, Bb) Full_slot(fs), here also four vacancies were provided ideal locations for storing the remaining containers unknown departure date (r2, t, Bb), we will only operate one location. (Scenario drawing see Figure (5)). See Figure 5. Scenario 1.

2.1.2 Scenario 2 (5 Containers Arrive with Known Departure Date)

We assume the arrival of five new containers on (27-Jan) with known dates, grouped as two containers on (3-Feb), one container on (1-Feb), and two containers on (5-Feb). To store the two departing containers on (5-Feb), either they are stored contrary to the chronicle range (non-adherence to the methodology) or in case of searching for a typical location based on the methodology, rearrange the row(r2) in the bay (Ba) or in (Bb) is the optimal solution for storing these two containers. In this case, the identification/selection of optimal locations for storing the remaining two containers departing on (3-Feb) will be clear and relatively fast, which will be on top of the previous containers (r2, t3 & t4, Ba or Bb).

So the remaining container that has a departure date (1-Feb) has four vacancies locations according to the current configuration, which is respectively (r1, t, Ba, or Bb), but according to the chronic method, the ideal location for this container is (1-Feb).

However, according to the chronic method, the ideal location for this container (1-Feb) is (r2, t1, Bb) being empty. See Figure 5. Scenario 2.

2.1.3 Scenario 3 (Reshuffled-containers (Reserved Bay))

The re-Reshuffled scenario illustrates how to provide vacant locations in the event of new containers arrival with reducing the operating cost. This process is carried out in the spare time of the equipment. According to the previous figure (Figure 4.), the container (24) that existed at the location (r6, t1, Ba) should move to the Reserved-Bay according to methodology. Because the methodology cannot deal with it due to exceeding the permissible period for staying in the yard and also emptying location (r2, t1, Ba) to allow storing new containers to which the balancing methodology applies. The ideal location in this case for the pre-existing container (r2, t1, Ba) Is the position (r1, t4, Ba) according to the time.

This process will provide eight vacant locations, which are (r2 & r6, t, Ba); likewise, the column (r2 & r6) in (Bay b) will be rearranged so that the container (20) (r6, t1, Bb) will be moved into the Reserved-Bay because it has exceeded the period; this process provides four vacancies in the column (r6, t, Bb); the column marked with row r2 is rearranged so the container (r2, t1, Bb) takes the vacant position (r1, t4, Bb) so we will get four vacant locations as well.

In general, the rearrangement according to the Paired-Bay methodology provides perfect vacant columns (r, t) within the Paired-Bay (4 * 4 = 16), enabling us to deal with any new storage with any period because it is empty.

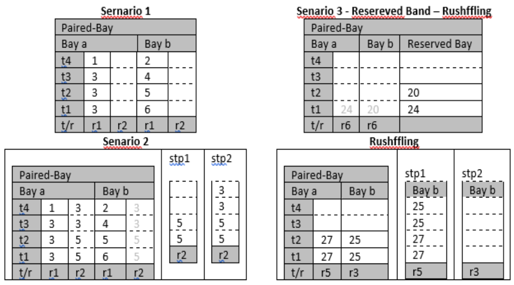

Figure 4: An illustration of the Scenarios

According to the parid-pay methodology and according to the data in the column (r5, t, Ba) and the column (r3, t, Bb) with a sequential date 25-27/Jan, the two columns can be combined according to their time-range sequence and this provides an ideal vacant column for storing new containers. See Figure 5. Scenario 3, 4. Previous scenarios reinforce our approach, merging two bays facilitates re-mixing and rearrangement of containers during equipment's spare time and provides good flexibility as well; as the two bays will share vacant sites in this situation. According to (Salebeh, T. & Debo, A., 2020), any container that has not been decided upon (for whatever reason), for example not being disbursed on time, is either moved to another location outside the yard, or a bay is allocated for containers that are not disbursed on time, according to the internal laws of container terminal management, a delay fine is imposed on these cases.

3 ARTIFICIAL INTELLIGENCE - ARTIFICIAL NEURAL NETWORKS

Artificial intelligence brings about change in management and operation processes. It can reduce human errors and make operations faster. Therefore, AI itself is part of a broader process of automation and improvement of port operations. The vision of artificial intelligence is represented by rational steps and organizational boundaries that help to improve key performance indicators; it serves to achieve common goals among the parties to artificial intelligence and promotes beneficial opportunities for all parties in real-time through prior knowledge of container movement patterns. We are looking forward to applying artificial intelligence, especially neural networks, in addressing the risk and errors of specifying vacant sites and choosing the optimal location for the container and this is what we will try to study in the next research by applying it to the data of the station (El Qasr El Saghir - Morocco) as a case study. In this paper, we focus mainly on the proposed methodology, and the proposal of neural networks in addressing this problem falls within the scope of planned future work because of its good ability to identify patterns and the diversity of methods of real-time prediction in the ideal empty location. Artificial Neural Networks (ANNs) are computer programs whose main goal is to simulate how the human brain processes information. ANN networks learn (or are trained) through experience with appropriate learning models and pool their knowledge by discovering patterns and relationships in data reference (Agatonovic-Kustrin & Beresford, 2000).

4 CONCLUSIONS

This study looked at the problem of storing containers in real-time at the container terminal. The problem was identified and a two-stage practical solution approach was proposed. The first phase, dividing the yard block into dual bays, involves the use of a proposed methodology for bay timing, while the time-bound container group approach is used in the second phase, which specifies the optimal location of the containers. The results of this study can be practically implemented by the El Qasr El Saghir station in Morocco. Through the simple scenarios, the possibility of the methodology appears in helping decision-makers store each container and track storage conditions. When the proposed method is applied to the reality in the station, it results in large, repetitive, and diverse data that require collection, purification, and processing to prove the effectiveness of the proposed method. In the future paper, we will process this big data using artificial intelligence to verify the effectiveness of the method.

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