The effective usage of Durres Seaport Container Terminal capacity using an Agent-based modelling approach.

Egi AGOLLI[1], Igli HAKRAMA[2]
[1,2]Department of Computer Engineering, Epoka University, Albania
eagolli12@epoka.edu.al, ihakrama@epoka.edu.al

Abstract
There are a lot of factors that affect the capacity of a seaport. Some of them are related to the physical assets and others with managerial issues. Due to the limited resources and high costs, it seems quite impossible for the container terminal authorities to increase the physical assets and hence increase the effective usage. Also there is not a clear understanding of how the increase of physical assets such as yard surface, cranes and other machines will influence in lowering the costs, high profit and high client satisfaction. This study has the aim to coordinate all the available inputs with the proper service algorithm in order to reduce the transportation costs of container and also to reduce the waiting time of ships and tracks. The representation of such a complex real situation will be unnecessary to be represented as a mathematical model. In this case the agent based model will be the proper one because the stimulation will measure in the model all the factors and will represent the effects that each of them has in the whole system. The implementation will be done by using Netlogo multi-agent programmable modeling environment. The results of the simulation also the analysis of data will be the proposals of using effectively the container terminal capacity.

Keywords: Agent-based modeling, seaport container terminal, simulation, optimization

Introduction

Due to the globalization the international trade during the last decade has increased, comparing only the statistics for 2013 an increase of 4.2 was the average annual percentage rate [1]. From the estimations that have been done 90 % of the world merchandise and commodity trade is done by ships. Those results comprise enough needed information to indicate the necessary need to invest on the effectiveness of seaport. That is the reason that the increasing the optimization and effective usage of container terminals has been in concerns of many researchers. In the case of Albania Durres seaport is one of the biggest port not only inside the country but also in the region. More than 30 % increase in the volume has been achieved through 2013-2014 due to privatisation and increase of the infrastructural investment. This fact shows us possibilities that exist in order to increase effectiveness of use in Durres Container Terminal. This paper aims to introduce an agent based model that describes the operations that are done in the terminal and try to analyse the factors that affect the system as a whole.

Operations in Container Terminal

Before going beyond on the analyse of the factors and the stimulation of all inputs, we will describe an overview of the Durres Container Terminal and the operations that are taken place there. Ports have been defined as "*natural sites for transhipment in order to transfer goods from one mode of transport to another"* [2]. Since seaports are key part of the supply chain, this increase the responsibility to coordinate in an efficient way all the operations in order to avoid bottleneck and to increase the overall performance.

The main part of a seaport is the container terminal which is defined as the place where the delivery of containers among agents is made. Container terminal is a complex system with different operations. We may group the operations in: main operations and complementary operations. In the first group we have a divide of *seaside* operations and *landside* operations. [3] Loading and discharging cargo from the ships are carried out by the seaside operations. On the other hand landside operations referees to processes where the containers that will be exported are dropped off and the containers that will be imported are picked up by trucks.

Other operations that support the main ones may be the container storage, opening and closing of hatches, container restacking shifting. Even though the complementary operations may not serve as basic operations, the increase number of such operations is a good indicator because shows: the infrastructural development and the desire to respond the customer need. Increasing the number and also the quality of those operations has a direct link with the increase of the customer believe and satisfaction.

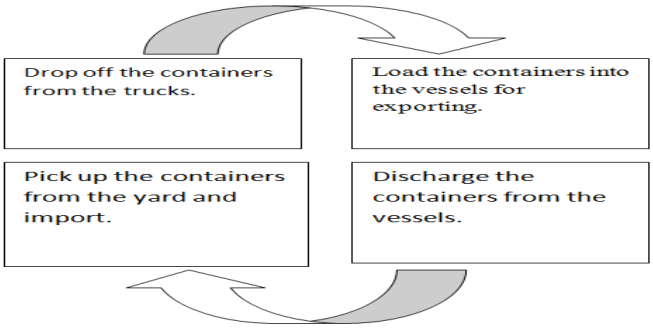

Figure.1 Description of the landside operations

When there are limited resources that may be used by the two types of operations it is very important to put priority in using them. In the container Terminal Durres in comparing the seaside and landside operations the seaside operation has the highest priority. When in function is only one cargo and one ship has to be discharged and 5 trucks have to pick up other container that are stored in the yard. All the staff and the crane will be used to discharged the ship. Even we put priority in responding with the resources (cargo and staff) the different processes they are connected together through a "cycle".

Factors that affect capacity

This paper will study and analyse factors that affect the effectiveness of Durres Container Terminal (DCT) capacity. The main concern that is against the effectiveness usage of any containers terminal is the *capacity*. According to the Islam and Olsen research [4] some of the physical factors that affect capacity are as follow:

- Container yard is defined as the surface where the containers are stored temporary. At the container yard are taken place the landside operations, the increase of this surface will lead to faster and easy access of the container by the cranes.
- Cranes are one of the most important equipment. The number of cranes, size and the system (automate or manually) that they use affect the operations by reducing the costs and increase the service quality by serving simultaneously to more than one truck or ship.
- Labour is very important to the container terminals that are not automatic or have a low level of automatically process. This is the case of DCT where the staff is divided in groups of six persons, and each group is responsible for the load and dispatching of the vessels or trucks.
- Traffic parameters affect the capacity by entering new lines, traffic peaking hours, and regular timetable.

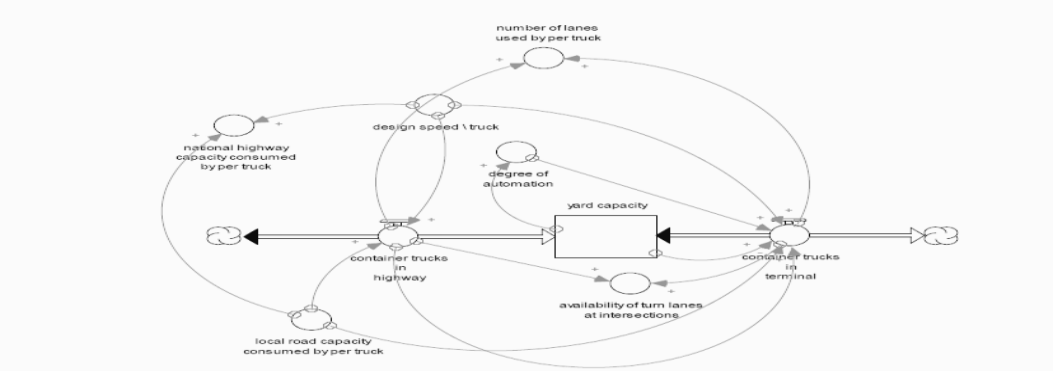

Figure.2 Causal Loop Diagram of yard capacity [5]

On the other hand there are also factors that are not physical but are linked with the managerial issues. Those factors play an important role because those factors affect not only the capacity directly but also the service quality and the management of assets. One of them is the *algorithm* that is chosen as a strategy to serve to customers. During 2013-2014 an amount of 5000000 Euro has been invested into the technological improvement and infrastructural into the DCT. This investment has had two important consequences:

- Increase the capacity by 30%.
- Reduce the waiting time of the ships for load/dispatch from 3 days that was in 2013 to 1 day. [6]

Those results shows that the investment has had a direct impact on the effectiveness but the financial or non-financial resources are limited (we cannot increase the container yard infinitely). On the research that Metalla, Koxhaj and Stana (2012) have done only to handle a 20 feet or 40 feet container at least five equipment are required:

- A portable crane with lifting capacity of 120 Tones.
- Two reach stackers with capacity 40 Tones.
- Two forklifts with a capacity of 35 Tones.
- Ten tractors and 20 trailers for the horizontal handling. [7]

Since the resources that are needed are in grade number and in high initial cost so it is a point where the increase of those investments will not lead efficiency in the capacity of DCT. For this reason the aim is to find an "*optimal algorithm*" in the process of selecting to which truck the crane will be available. This is the scope of the paper, comparing different service algorithm and figure out the optimal one that will increase the effectiveness in the case of DCT.

Measurement of the performance DCT

In order to find the "*optimal algorithm*" in the process of serving the cargo to the trucks, it is important to define standards that will serve as measurement to compare the different algorithms. As standards we will use measurement of performance at the landside operations. Even though there are different type of classification Thomas and Monie (2000) make this dived of measurements into production, productivity, utilization and service measures [8] . We will use the road vehicle waiting time that is under the service measures as a standard. Road vehicle *waiting time* is the time required that the vehicle has to wait to collect a container or deliver one in the terminal.

Agent-based model

To represent a complex process and transform it into the model, linear regression model may be used or represented it as an agent-based model (ABM). ABM allows you to study the economic or social events, processes in different and new perspective. That makes the main reason why we used ABM to represent the landside operations of CDT to determine the optimal algorithm for service time. The agents represent economical units and economic entities [9]. The agents have different attributes and behaviour and those characteristic differential them. To use the agents into the software we have to code the attributes and behaviour in order to represent the real economic situation. The effect of visualizing and opportunity of interaction between agents has made that only into the last years a host of agent based modelling language to be developed. Netlogo is a multi-agent programming language and modelling environment for stimulation social, economic and natural phenomena [10]. It gives the commodity for users, student and researcher to explore with the variable into the model, stimulate the attributes and behaviour. Using the tool such as BehaviorSpace gives the researcher the results of more than one run of the stimulation in different format.

Model representation of DCT

Many of the researches that have been done for crane service strategy have used as method linear regression or other mathematical techniques. The following researches have been done using stimulating and the result different from each other because of the assumption of the model.

Petering (2009) [11] made a research based on several simple heuristics in yard crane and the results indicate that the prioritizing retrieval moves over storage moves gives a superior system. During the operation a deadlock may be achieved, to avoid this they proposed short planning periods.

In the study of Nathan Huynh and Jose M. Vidal [12] the stimulation is done by Netlogo and based on that model we have make changes in adding service algorithm and changing attributes to be more representative of the Durres Container Terminal (DCT).

Model is represented in a patch with 8 yard group and with roads that bound each of the group. The distribution of the container on the yard is made randomly. Trucks are arriving to the yard and to be served in a random Poisson distribution. Also the time that is needed to remove the container into the same stuck is higher than [12] it is 60 ticks and the time to deliver the crane to truck is 100 ticks. We have made the assumption that the size of the container is 40 feet and the time to load one of them into the truck is fixed 100 ticks, the time after the truck allocate to crane and it go out of terminal is same for all. The change and problem is to access the cargo.

Crane is one of the most important assets but it is limited in the shipping process. During the landside operations trucks have to access the crane in order to load or unload the cargo. Once a crane is associated to a truck it cannot interrupt its process. This situation is an analogy of the situation where the CPU has to be allocated to different processes, we will use that algorithm to determine the *optimal algorithm of service strategy*. In this case analogy to CPU is the crane, trucks are the processes, the crane use non-preemptive approach since it is allocated to a truck it has to deliver the cargo to that truck and then continue with the other one. The algorithms are First come First serve, Priority, Randomly, Closest.

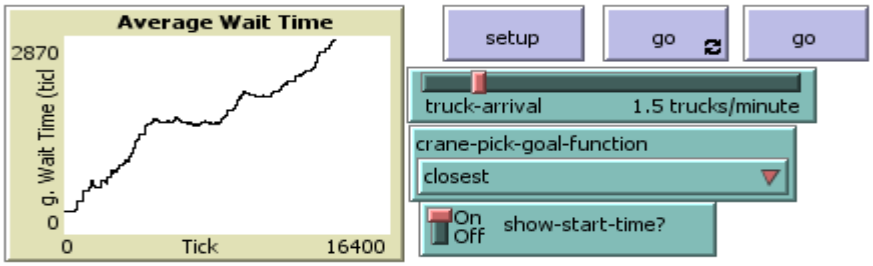

Figure.3 Closest algorithm result in an average waiting time of 47.83 minutes (2870 sec)

Trucks are serving in the order than they are arriving in the waiting gate. The truck that are waiting first, allocate the crane first. This algorithm is not an optimal one because since the time of load the cargo is fixed the trucks that came late will have to wait in huge amount of time comparing with those who came first.
Priority will be putted on the customer (main customers are MCS, Pelican, Zim, Cma Cmg) annual volume profit. This priority will lead to starvation since only the biggest customer will be served and will cause decrease of the market completion.
One solution of the starvation may be aging by increasing the priority of the trucks by adding priority when their waiting time increases the limit of 40 min.
Closest algorithm [12] allocate the crane to the truck that is closest to them and reduce the turn often, this algorithm provide the lowest waiting time.
Randomly algorithm [12] allocates the crane to the truck chosen randomly. At the beginning the two cranes will be allocated to the first truck and the second truck that comes first. After this allocation if the number of trucks that have arrived is bigger than 2 the cranes will be allocated to the tracks randomly. This algorithm produces an average waiting time of 65 minutes. Comparing with the FCFS algorithm produces better results but translates the algorithm into the concepts of the operations it will be very difficult. Choosing randomly the trucks by the cranes dissatisfaction will occur.

Conclusion

This paper introduces different service algorithms that increase the efficiency at Durres Container Terminal. In this study the service algorithm is linked with the landside operations. Landside operations include the processes as load the cargo to the truck and unload the cargo from the truck. As the measurement tool of efficiency we have chosen the average waiting time of the truck. The stimulation is done using Netlogo agent- based model. From the results of the different algorithms we conduct that the lower average waiting time is achieved by the closest algorithm.

Closest algorithm [12] allows the crane to be allocated to the truck that is closest to the previous truck that finishes the process of loading/unloading. A sample of 100 runs of the stimulation produces an average of 47.83 minutes waiting time, with the arriving trucks rate 1.5 trucks/ minute. Closest algorithm needs the trucks to be positioned to the row where the cargo is, since the surface of DCT is only 64 000 m² this will lead to congestions and lack of necessary spaces. We proposed to determine a limit on the number of trucks that may wait at the row inside the yard.
In focus of our future work is to increase the scope of the model by inserting also the seaside operations (ships loading and unloading) simultaneously with the landside operations. This will make the model a real representation of the reality and produce crucial data that may be useful to managerial processes.

References

[1] WTO, «World Trade Organization,» 2014. Available: https://www.wto.org/english/res_e/booksp_e/wtr14-1_e.pdf.

[2] Carbon, Valentina; Marcella De Martino, «The changing role of ports in supply-chain management: an empirical study,» *Maritime Policy & Management,* pp. 305-320, October 2003.

[3] B. Brinkmann, «Operations Systems of Container Terminals:».

[4] S. Islama T.L. Olsena, «Factors affecting seaport capacity,» *International Congress on Modelling and Simulation*, Perth, Australia, 2011.

[5] S. Islama T.L. Olsena, «Factors affecting seaport capacity: Managerial implications for a simulation framework,» në *National Conference of the Australian Society for Operations Research*, Adelaide, Australia, 2013.

[6] «Durres Container Terminal,» Available: http://dct.al/.

[7] Osman Metalla, Andri Koxhaj, Alma Stana, «Optimization Of Operations In Durres Port Container Terminal,» *Romanian Economic and Business Review.,* vëll. i VII, nr. 3, pp. 55-64, 2012.

[8] S. Esmer, «Performance Measurements of Container Terminal Operations,» *Sosyal Bilimler Enstitüsü Dergisi,* pp. 238-255, 2008.

[9] I. Hakrama, «Artificial Economy and the usage of ACE,» 5th International Conference on *Information Systems and Technology Innovations: projecting trends to a New Economy*, Tirane Albania, 2014.

[10] Seth Tisue, Uri Wilensky, «NetLogo: A Simple Environment for Modeling Complexity,» në *International Conference on Complex Systems*, Boston , 2004.

[11] Wenkai Li, Yong Wu, Matthew EH Petering, Mark Goh, and Robert de Souza, « Discrete time model and algorithms for container yard crane scheduling,» *European Journal of Operational Research,* vëll. i 198, nr. 1, p. 165–172, 2009.

[12] Nathan Huynh, Jose M. Vidal, «An Agent-Based Approach to Modeling Yard Cranes at Seaport Container Terminals,» në *Proceedings of the Symposium on Theory of Modeling and Simulation*, 2010.

Egi AGOLLI is a Bachelor Student at Epoka University, studying in the Faculty of Economics and Administrative Sciences, Department of Business Informatics, Business Informatics program.

Igli HAKRAMA is a PhD Candidate at University of Tirana in the Department of Applied Informatics and Statistics. He has graduated from the Business Informatics programme under the same department in 2008 and holds two master degrees, one in European Economic Studies and another in Computer Engineering. He currently works as a lecturer in the department of Computer Engineering at Epoka University, where he has taught since 2009. His teaching activity has been focused on object oriented programming, web and software Engineering. His research focus is in artificial intelligence area and its implementation in the economic field, he is currently working on building agent-based models for economy by using AI algorithms.