System Approach to the Simulation of Transport Infrastructure of Container Terminals

Sustavni pristup simulaciji transportne infrastrukture kontejnerskih terminala

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Summary

This article describes a systematic approach to the simulation and provides practical application of the seaport infrastructure analysis.

KEY WORDS
logistics, simulation, transport infrastructure, seaport, modeling

Sažetak

Članak opisuje sustavni pristup simulaciji i prikazuje praktičnu primjenu analize infrastrukture morskih luka.

KLJUČNE RIJEČI
logistika, simulacija, transportna infrastruktura, morska luka, modeliranje

INTRODUCTION / *Uvod*

Simulation as a method of imitation of operations in a real-world processes and systems can be used to describe and analyse the behaviour of an existing and conceptual systems especially in the container terminals, traffic and transportation. Hence, this can be a fruitful method of searching the optimal solution by integrating efficient algorithms and also a part of a system supporting decision making.

The main goal of the Working group chairman in charge of the system analysis and logistics at the St. Petersburg state university of Aerospace Instrumentation consists of the preparation of future experts in the field of simulation of transport processes. Since St. Petersburg is a big seaport, the majority of students, within the training practice at the University, solve problems of modelling of the port transport infrastructure. The globalization combined with the success of containerization has brought about tremendous increases in the transportation of containers across the world. This leads to an increasing size of container ships which causes higher demands on seaport container terminal and resides in a fast transshipment process with reduced costs. For these reasons it is necessary to optimize the terminal's processes. For the best optimization we must work with simulation model of this object.

Let us look at the main approaches to modelling of transport processes and we shall consider an example of its realization in seaport and we focus separately on modelling of intellectual systems of transportation:

DISCRETE EVENT SIMULATION / *Diskretna simulacija*

Discrete-event simulation supports hierarchical modular model construction, distributed execution, and therefore affords a basis to characterize complex, large-scale systems using formulation of components and their interactions. It is used to simulate components which normally operate at a higher level of abstraction than components simulated by continuous simulators. Within the context of discrete-event simulation, an event is defined as an incident which causes the system to change its state in some way - a new event is created whenever a simulation component generates output. A succession of these events provides an effective dynamic model of the system being simulated. The events in a discrete-event simulator can occur only during a distinct unit of time during the simulation - events are not permitted to occur in between time units. This feature of discrete-event simulation separates it from continuous simulation which is generally less popular in traffic simulation because it is usually slower and does not provide a reasonably accurate approximation of a system's behaviour, especially, flowing elements.

MICROSCOPIC SIMULATION [1,2] / *Mikroskopska simulacija [1,2]*

Microscopic simulation is the technique which provides a realistic measure of traffic flow on a network as well as the

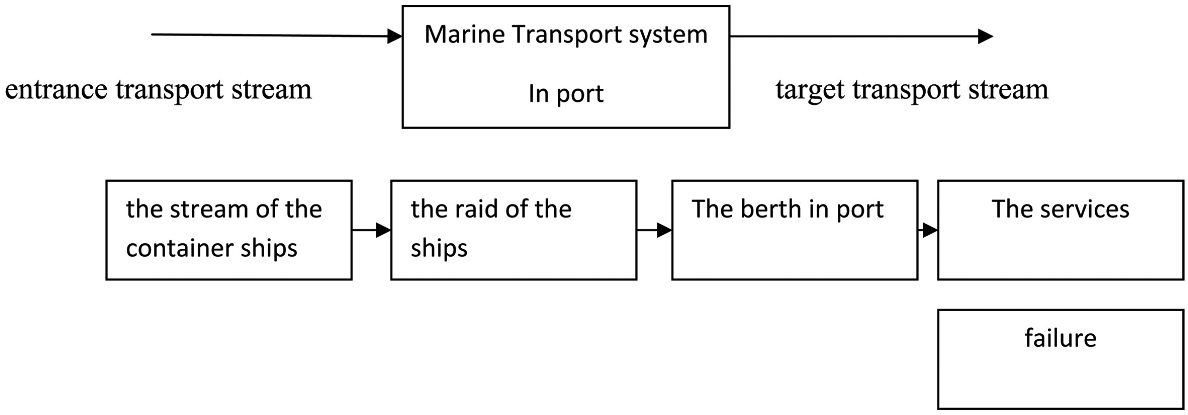


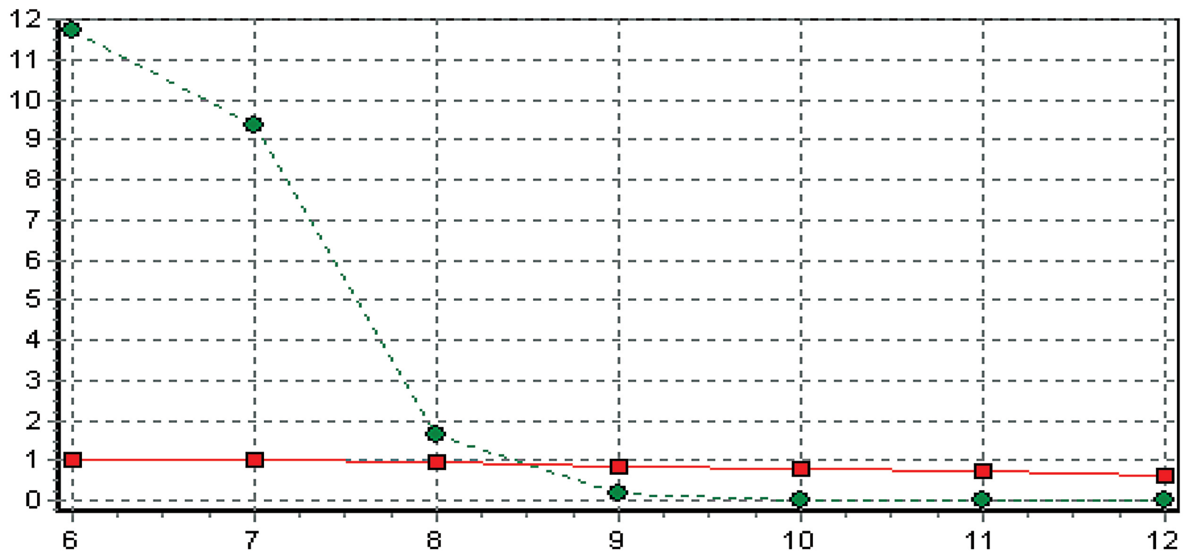
Fig. 1. The generalized scheme of single-channel transport system of mass service and Structure of transport model of the sea terminal
Slika 1. Generalizirana shema transportnog sustava širokih usluga jednim kanalom i struktura transportnog modela za terminal morske luke

variety of type and number of transport objects. In the past describing the traffic was possible using macroscopic approach which perceived the traffic as a fluid flowing along the carriageway. Microscopic approach allows to study the traffic flow by modelling the motion of a particular transport object. The mathematical models used in it are called "car following models".

Since each transport object could be autonomous, the realism of each object's behaviour could correspond to the geometry of the road network as well as each object's and its driver's behaviour could be determined by individual set of mathematical rules according to its type. Objects-following and overtaking as well as driver's awareness and aggressiveness could be modelled in this way. The crucial aspect of any microscopic simulation model is a calibration of parameters describing transport object and the environment.

MODELLING ON THE BASIS OF MASS SERVICE SYSTEM / *Modeliranje temeljem sustava širokih usluga*

in analytical research of transport systems, a complete research manages to be carried out when obvious dependences, connecting the required sizes with parameters of system and entry conditions of its studying, are received. However, it can be executed only for rather simple transport systems. The analysis of characteristics of the functioning processes of difficult systems



The number of berth	6	7	8	9	10	11	12
Average waiting time	11.7	9.37	2.08	0.141	0.0183	0.00202	0.000155
Average idle time	0.00153	0.00232	0.199	1.18	2.18	3.2	4.23

- factor of loading
- average waiting time

Figure 2 Schedule of loading of transport system and average waiting time
Slika 2. Raspored ukrcaja transportnog sustava i prosječno vrijeme čekanja

by means of only analytical methods encounters considerable difficulties resulting in the need for essential simplification of models with doubtful results. Therefore, more often the imitating models are used for the research of transport systems. When using a discrete approach for the creation of imitating models as the formalized representations of the modelling objects, the following abstract schemes of three main types are usually used: systems of mass service, automatic systems and aggregate systems.

Let us consider sea logistic system in which cargo vessels come to unload [2,4,5]. Time of arrival of a vessel to the port is distributed normally with a population mean of m = 1 and an average quadratic deviation σ = 0,3. Unloading of each vessel is carried out around one from n of moorings, each of which can serve at the same time only one vessel. The vessel coming to the port for unloading to the released mooring and if all moorings are occupied it stands in line on raid. Time of unloading is evenly distributed. Each vessel comprises one of 3 categories: the first, the second or the third. Vessels with higher category take precedence in unloading.

Work of any system of mass service consists of servicing a stream of requirements arriving on it, or demands, in this case vessels. Demands arrive on system one after another, but more often in occasional moments in time. Service of the arrived demand proceeds any time when the system is released for service of the next transport demand. The generalized scheme is represented in Figure1.

It is necessary to execute modelling to solve the problem of optimum port infrastructure performance. It is necessary to investigate the factor of loading system and an average waiting time of a vessel for unloading. The result of modelling is given in Figure 2.

Thus, having analysed dependences it is possible to come to a conclusion that for effective functioning of port, 8 or 9 berths are necessary. This information should be used for further decision-making on port work for more rational use of resources (berth) and finding the optimum service quality.

AGENT BASED SIMULATION / *Simulacija agentom*

agent based approaches are widely used in network applications and they are currently one of the most attractive and rapidly evolving software technologies. An agent concept is used to describe the concept of an entity that automates some tasks. It emerged from a specialized class of distributed artificial intelligence. Agents can be perceived as autonomous, proactive and reactive entities that can exhibit the ability to learn, co-operate and move. In order to use agents in traffic simulation, agents must be able to migrate from node to node in network and interact with their environment. Agent-based solutions are suitable for management of transportation systems with logic embedded to its elements.

Simulation modelling is made in the environment of AnyLogic [3]. On an entrance of system the stream of the ships which wait for unloading near berths or are on the way to them in the port water area. The port contains a certain number of berths which can process vessels. At imitating modelling generation of various numbers of vessels is carried out. The first stage loads the map of the port. Then special polylines on which vessels will move are drawn. The simulation model is given in Figure 3.

As a result of the simulation model, qualitative and graphic characteristics of operation of blocks “a stream of the ships”, “raid”, “berth” are specified in Figure 1. Apparently in Figure 1 three transport streams and berths are set and cannot cope with a certain entrance stream of vessels. The turn from the vessels which expect unloading increases. Quantitative characteristics of this transport process are a basis for calculation of optimum number of moorings which will provide optimum performance

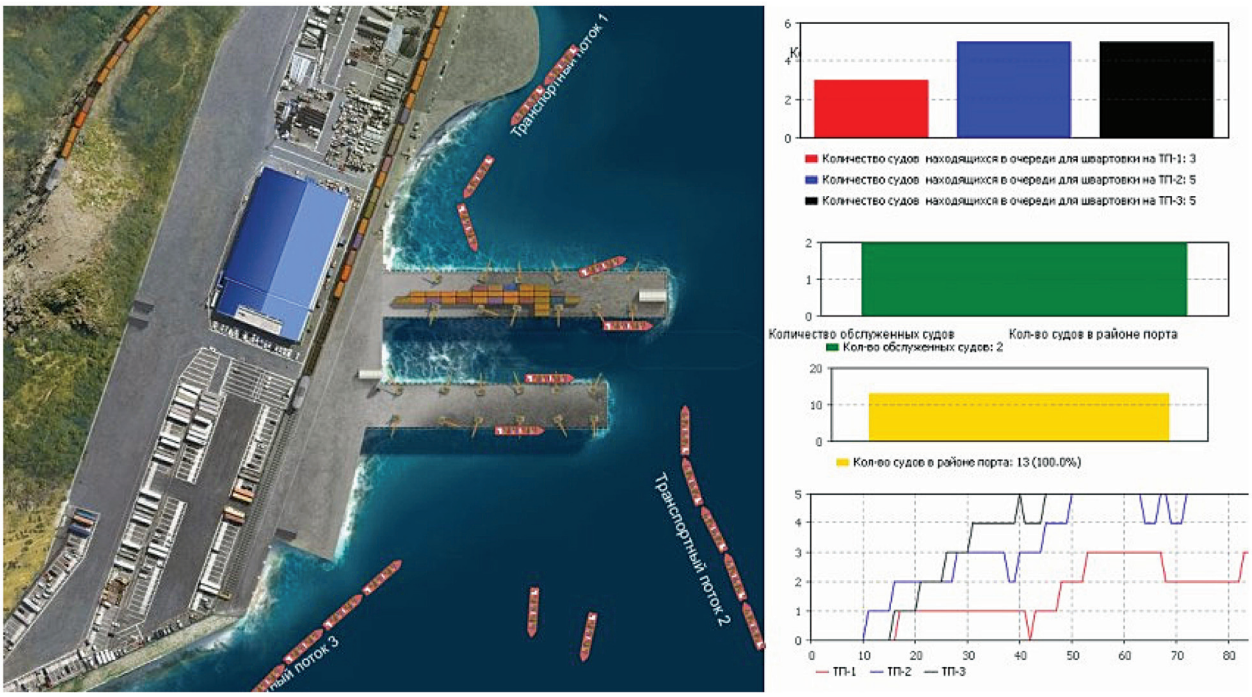


Figure 3 Simulation model of vessels in the sea port (example)
Slika 3. Simulacijski model plovila u morskoj luci (primjer)

of a port complex. Results of calculation and graphic characteristics are given in Figure 2.

CONCLUSION / *Zaključak*

It is evident that from the given calculations needed for the solution of tasks regarding the optimum work of transport system (as in port system article), it is necessary to have the knowledge of various mathematical techniques, software products of simulation and a system approach to the solution of multicriteria tasks. The method presented in this article is applicable to the study of such objects as "dry ports" and the system of international airports and other transport systems.

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