System Approach to the Simulation of Transport Infrastructure of Container Terminals

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

**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
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

![Figure 1. The generalized scheme of single-channel transport system of mass service and Structure of transport model of the sea terminal](image1)

![Figure 2. Schedule of loading of transport system and average waiting time](image2)
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 \(\sigma = 0.3\). 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
time. 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 Figure 1.

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
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
load 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.

REFERENCES / Literatura