The Methodology of the Customers’ Operation from the Seaport Applying the “Simple Shuttle Problem”

The paper deals with one of the most significant fields of the application of mathematical calculations to optimize the operational research and traffic problems. This issue includes the distribution of goods from the source/sources (seaport in our case) to dispersed targets (customers). The application of the “simple shuttle problem” is one option of the transport problem solution.

Summary

This paper deals with one of the most significant fields of the application of mathematical calculations to optimize the operational research and traffic problems. This issue includes the distribution of goods from the source/sources (seaport in our case) to dispersed targets (customers). The application of the “simple shuttle problem” is one option of the transport problem solution.

1. INTRODUCTION / Uvod

Calculations based on the compilation of algorithms may be included as part of the significant field of using mathematical calculations for optimization and operational research of traffic problems. Generally, these calculations relate to distribution of goods from the source(s) to the dispersed destinations. The use of the “Simplex Method” is one of the possibilities for solving the transportation problem.

This example deals with the special group of traffic problems which can be called “shuttle traffic problems”. The goods must be delivered from the supply logistics object $S_0$ (seaport in our case) to the selected customers (for example the distribution centres placed in the selected area), $(S_1, S_2, \ldots, S_n)$, which are supplied consecutively [1], [2].

$d_i$ denotes the distance between $S_p$ and $S_i$ and the determination of the optimal supply sequence which minimizes the total waiting time of customers for supplied goods is the target problem [1], [2].

This particular example relates to the typical “shuttle traffic problems”, which means that the individual problems depend on the total waiting time of customers.

2. OVERVIEW OF THE UTILIZED LOGISTICS SOLUTIONS FOR SUPPLIES / Pregled korištenih logističkih rješenja za dopremu

The distribution centres supply utilizes four types of goods supply [3]:

a) Direct: the goods are supplied directly to the customers,

b) Cross – docking: flow- through of goods (with or without transhipment in docks) but goods are not stored (system of immediate goods reloading),

c) Central warehousing: supply from one or more central logistics objects,

d) Direct full truck loads: the goods are supplied to the customers in full truck loads.

3. SEAPORTS / Pomorske luke

Seaports are the key factors of the maritime and traffic system. Seaports have become essential nodal components of freight transport networks. The concept of seaports relates to the specialized zones offering space and common services to water and other transport operators, logistics providers, and shippers. Usually, a seaport is an enterprise that owns and organizes the
Seaports can generate internal and external effects. The internal effects refer to advantages for users in sharing the total acquisition and operating costs of common facilities, equipment, and services offered, without heavy and risky investments in building their own. Other benefits stem from the increased interaction among users. Freight seaports also generate larger-scale or external (network) effects, such as traffic diversion and modal shift, land use reorganization, changes in the local economy and employment, lower energy consumption and environmental benefits [5].

Seaports are an acknowledged part of national economy, they directly influence the growth of certain sectors and they are a precondition for growth of other branches of industry such as energy industry. To be competitive in the market, a seaport has to meet certain market demands. A well-devised marketing logistics is a key factor for port’s development and for its high competitiveness [6][13].

4. SEAPORT TRANSPORTATION SERVICES / Usluge prijevoza u luci

Distribution of goods depends on transportation. This is because transportation services in a region rely on the transportation network and its development, integration, charges, assortments and the quality service. Seaports develop various activities related to consolidation: warehousing, storage, handling operations, shipment coordination, services to transport modes, transport units, and human resources, banking and other cargo administrative services. They can include many other accompanying activities: packaging, coding, marking, palletizing, labelling, as well as stowing goods in containers, etc. The core of logistics is: creating added value through the fast, efficient, and quality transportation of freight by different means of transport that are at one’s disposal [5], [6].

Transportation comprises not only transportation services but all other services that are connected with its preparation and realisation and they refer to: passenger and goods moving, loading, unloading, cargo transfer, storage, changing means of transport, preparation, renting, delivery of new and overhauled means of transport etc. [7] [12].

Port transportation services are defined as all activities related to the transfer of cargo in any port’s space and time, as well as performing accompanying port services such as: packaging and/or storage in accordance with physical characteristics of cargo, transferring, labelling, coding, special labelling, formation of measuring units, unified unit of transportation, palletizing, placing goods in containers, choice of ideal form of transport and port’s means of transport, use of contracted means of transport, use of modern technology and access when dealing with both cargo and supplies in port warehouses or terminals and use of modern information technology, as well as computer support [5], [7].

5. THE MODEL OF CUSTOMERS´ OPERATION FROM THE PORT APPLYING THE “SIMPLE SHUTTLE PROBLEM” / Model rada s klijentima od pomorske luke uz primjenu jednog prijevoznog sredstva “simple shuttle problem”

The whole “simple shuttle problem” issue includes one particular part called “greedy algorithm”. The greedy algorithm is a mathematical process that looks for simple, easy-to-implement solutions to complex, multi-step problems by deciding which next step will provide the most obvious benefit [2-4].

Such algorithms are called “greedy” because while the optimal solution to each smaller instance will provide an immediate output, the algorithm doesn’t consider the larger problem as a whole. Once a decision has been made, it is never reconsidered [2-4].

Greedy algorithms work by recursively constructing a set of objects from the smallest possible constituent parts. Recursion is an approach to problem solving in which the solution to a particular problem depends on solutions to smaller instances of the same problem. The advantage to using a greedy algorithm is that solutions to smaller instances of the problem can be straightforward and easy to understand. The disadvantage is that it is entirely possible that the most optimal short-term solutions may lead to the worst possible long-term outcome [2-4].

The essence of a “simple shuttle problem” is to minimize the customers total waiting time for goods [4]:

$$\sum_{i=1}^{n} t_i$$

where \( t_i \) = waiting time of the customer \( S_i \)

It is assumed that carriage of goods between \( S_j \) - supply (seaport) warehouse and the customer \( S_i \) is carried out by one articulated vehicle and also that the vehicle returns to the starting supply point (seaport) \( S_0 \) after the supply of goods [2],[4].

For constant articulated vehicle speed, waiting times \( t_i \) may be replaced by the travelled distance \( d_i \) between the starting supply point and the individual customers \( S_i \) [2], [4].

\[
t_i=d_i,
\]
\[
t_i=t_i+(d_i+d_j)=2d_i+d_j,
\]
\[
\ldots
\]
\[
t_i=t_{n-1}+(d_{n-1}+d_n)=2d_n+2d_{n-1}+\ldots+2d_1+d_0
\]

where \( d_i = d_i \) travelled distance between the starting supply point and the customers \( S_i \)

View of the goods distribution from the starting point (seaport) \( S_0 \) to the customers (\( S_i \)) is shown in Figure 1.

![Figure 1 View of the goods distribution from the starting point (seaport) \( S_0 \) to the customers (\( S_i \))]
In order to substitute the values $d_i$ to the formula, it is necessary to determine the actual distances between a particular seaport and the individual distribution centres in the selected area. These distances are shown in the following Table 1.

The next step in the process is to order the distances between the seaport and individual distribution centres from the shortest to the longest distance (see Table 2).

The total waiting time may be expressed by the objective function:

$$\sum_{i=1}^{n} t_i = (2n - 1).d_1 + (2n - 3).d_2 + \cdots + 3d_{n-1} + d_n \quad (3)$$

Since $n$ is fixed to minimize the total waiting time, it is necessary to select for $d_1$ the shortest distance, for $d_2$ the second shortest distance, etc, and for $d_n$ the longest distance, this means to use the supply sequence from Table 2.

Individual distances, which one articulated vehicle travels when supplying the distribution centres from one starting supply point, are determined by using the selected algorithm within the issue of "simple shuttle problem".

Table 3 contains the results of the above mentioned procedure, where the distances are shown and ordered. These distances refer to the operation (supply) of the distribution centres by one articulated vehicle when operating from the selected seaport to the customers with the resulting data about total travelled distance $t_i$ of one vehicle to new distribution centre $S_i$ [11]. Similar optimization approach can be seen in papers [14], [15].

In this particular case, the optimal supply sequence is 5, 12, 2, 1, 11, 7, 9, 3, 15, 6, 14, 13, 4, 10, 16 and 8.

Determination of the total driving performance and also the total waiting time of the customer (given in km) when using one supply articulated vehicle for operating the distribution centres is the final output of above realised calculations.

This driving performance is $\sum_{i=1}^{n} t_i = 2452$ km.

6. CONCLUSION / Zaključak

This paper is focused on the simple algorithm within the issue of the “simple shuttle problem”, which helps to solve the distribution problems. In our case, it was able to determine the optimal supply sequence within the customers’ operation from the selected seaport [8-9].

Generally, the algorithms for typical optimization problems go through a sequence of steps with the simple choices of steps until complete solution. This particular algorithm, (the “simple shuttle problem”), consists of small parts of calculations. The determination of the total customer waiting time for goods, which refers to the transport distances, is the final output of this algorithm. These distances do not contain time required for loading and unloading [4], [10].

Table 1 The Distances between the Selected Seaport and the Individual Distribution Centres

<table>
<thead>
<tr>
<th>$S_i$</th>
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<th>$S_{14}$</th>
<th>$S_{15}$</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$d_i$ [km]</td>
<td>12</td>
<td>11</td>
<td>23</td>
<td>36</td>
<td>10</td>
<td>32</td>
<td>18</td>
<td>59</td>
<td>22</td>
<td>47</td>
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<td>33</td>
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Source: authors

Table 2 The Order of the Distances between the Seaport and Individual Distribution Centres

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<td>34</td>
<td>36</td>
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</table>

Source: authors

Table 3 The Resulting Order of Distances with the Results of the Travelled Distances ($t_i$) by One Vehicle

<table>
<thead>
<tr>
<th>$S_i$</th>
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REFERENCES / Literatura


