The Methodology of the Customers' Operation from the Seaport Applying the "Simple Shuttle Problem"

Metodologija rada s klijentima od pomorske luke uz primjenu transportnog problem s jednim prijevoznim sredstvom ("simple shuttle problem")

Ondrej Stopka
Department of Transport and Logistics
Institute of Technology and Business
České Budějovice, Czech Republic
e-mail: stopka@mail.vstecb.cz

Jozef Gašparík
Department of Transport and Logistics
Institute of Technology and Business
České Budějovice, Czech Republic
e-mail: 12971@mail.vstecb.cz

Ivana Šimková
Department of Research and Development Transport Research Institute
e-mail: simkova@vud.sk

DOI 10.17818/NM/2015/4.7
UDK 656.71 : 519.8
Original scientific paper / *Izvorni znanstveni rad*
Paper accepted / *Rukopis primljen:* 21. 11. 2014.

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.

KEY WORDS
seaport
simple shuttle problem
customers
operation
supply

Sažetak

Ovaj rad bavi se jednim od značajnih područja primjene matematičkih izračuna u optimizaciji operativnih istraživanja, s primjenom za transportni problem. Ovo pitanje uključuje distibuciju robe od izvora (u našem slučaju pomorske luke) do raspršenih ciljeva (klijenti). Primjena jednog prijevoznog sredstva (simple shuttle problem) jedna je od opcija pri rješavanju transportnog problema.

KLJUČNE RIJEČI
Pomorska luka
problem jednog transportnog sredstva
klijenti
operacija
doprema

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 (sources) 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, . . . ,S_n), which are supplied consecutively [1], [2].

d_i denotes the distance between S_0 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 site and manages and provides certain services and facilities to companies established in the port, providing open access to them [5].

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]:

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

where t_i = *waiting time of the customeri* S_i

It is assumed that carriage of goods between S_0 - 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].

$$\begin{aligned} &t_1=d_1\\ &t_2=t_1+(d_1+d_2)=2d_1+d_2\\ &.\\ &.\\ &.\\ &t_n=t_{n-1}+(d_{n-1}+d_n)=2d_1+2d_2+\ldots+2d_{n-1}+d_n \end{aligned} \tag{2}$$

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 (*Si*) is shown in Figure 1.

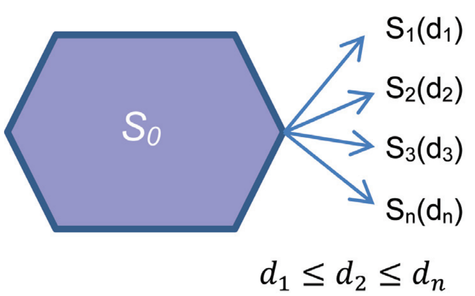

Figure 1 View of the goods distribution from the starting point (seaport) S_0 to the customers (S_i)

Slika 1. Prikaz distribucije roba od početne točke (zračna luka) S0 do klijenata (Si)

Table 1 The Distances between the Selected Seaport and the Individual Distribution Centres
Tablica 1. Udaljenost između odabrane zračne luke i individualnih distribucijskih centara

S_i	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}
d_i [km]	12	11	23	36	10	32	18	59	22	47	16	10	34	33	29	53

Source: authors

Table 2 The Order of the Distances between the Seaport and Individual Distribution Centres
Tablica 2. Poredak udaljenosti između zračne luke i individualnih distribucijskih centara

S_i original	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}
S_i new	S_5	S_{12}	S_2	S_1	S_{11}	S_7	S_9	S_3	S_{15}	S_6	S_{14}	S_{13}	S_4	S_{10}	S_{16}	S_8
d_i [km]	10	10	11	12	16	18	22	23	29	32	33	34	36	47	53	59

Source: authors

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 3 The Resulting Order of Distances with the Results of the Travelled Distances (ti) by One Vehicle
Tablica 3. Dobiveni poredak udaljenosti s rezultatima prijeđenih udaljenosti (ti) za jedno vozilo

S_i orig.	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}
S_i new	S_5	S_{12}	S_2	S_1	S_{11}	S_7	S_9	S_3	S_{15}	S_6	S_{14}	S_{13}	S_4	S_{10}	S_{16}	S_8
d_i [km]	10	10	11	12	16	18	22	23	29	32	33	34	36	47	53	59
t_i [km]	10	20	31	43	59	77	99	122	151	183	216	250	286	333	386	445

Source: authors

ACKNOWLEDGEMENT / *Zahvala*

This paper has been developed under support of project: MŠVVŠ SR VEGA No. 1/0320/14 Poliak, M.: Increasing the road transport safety through the support of public passenger transport.

REFERENCES / *Literatura*

[1] Peško, Š., M. Pončák. Lagrangian heuristic for fastidious travelling salesman problem, Mathematical, econometrical and computational methods in finance and insurance. Katowice: University of Economics. pp. 223-229. ISBN 83-7246-811-7. 2006.

[2] Yujun, Z., Chuanqing, X., Jinyun, X. A. Simple greedy algorithm for a class of shuttle transportation problems. Optimization letters. September 2009. Vol. 3(4). pp 491-497. ISSN 1862-4480. 2009.

[3] Lambert, D., Stock, J., Ellram, L. Fundamentals of Logistics Management. Praha: Computer Press. 589 p. ISBN 80-7226-221-1. 2000.

[4] Black, P. E., "Greedy algorithm". in Dictionary of Algorithms and Data Structures. [online]. VredaPieterse and Paul E. Black, eds. 2 February 2005. (accessed TODAY) Available from: http://www.nist.gov/dads/HTML/greedyalgo.html. 2005.

[5] Seaport Intermodal – Official website of the company. © 2014 Seaport Intermodal. [online]. [quoted: 08.28.2014]. Available from Internet: http://seaportint.com/.

[6] Drašković, M. Integrisana marketing logistika u sistemu menadzmenta luke Bar. 20., 69., 83., 84., 46., Kotor. 2008.

[7] Tauzović, J., Sistemska teorija upravljanja. II dio, primjena u morskom brodarstvu i lukama, 691., 689., Podgorica. 2001.

[8] Stopka, O., Kampf, R., Kolář, J., Kubasáková, I., Savage, CH. Draft guidelines for the allocation of public logistics centres of international importance. In: Communications: scientific letters of the University of Žilina. Vol. 16 (2). pp. 9-13. ISSN 1335-4205. 2014.

[9] Kampf, R., Lizbetin, J., Lizbetinova, L., Requirements of a transport system user. Communications. Vol. 14 (4). pp. 106 – 108, ISSN: 1335-4205. 2012.

[10] Kampf, R., Průša, P., Savage, C. Systematic location of the public logistic centres in Czech Republic.Transport 26 (4) pp. 425 – 432, ISSN: 1648-4142. 2011.

[11] Majerčák, P., Klieštik, T., Masárová, G., Buc, D., Majerčáková, E.,System approach of logistic costs optimization solution in supply chain. Naše more: znanstveno-stručni časopis za more i pomorstvo. Vol. 60 (5-6). pp. 95-98, ISSN 0469-6255. 2013.

[12] Poliak, M., Konečný, V., Factors determining the electronic tolling scope of road network. Journal of economics. Vol. 56 (7). pp. 712-731, ISSN 0013-3035. 2008.

[13] Poliak, M., Impact of road network charging system on pricing for general cargo transportation. Traffic& Transportation: scientific journal on traffic and transportation research. Vol. 24 (1). pp. 25-33, ISSN 0353-5320. 2012

[14] Poliak, M., Impact of road network charging system on pricing for general cargo transportation. Traffic & Transportation: scientific journal on traffic and transportation research. Vol. 24 (1). pp. 25-33, ISSN 0353-5320. 2012

[15] Krile, S., Passage Planning with Several Ports of Loading and Discharging, Planiranje plovidbe s više luka ukrcaja i iskrcaja, Naše more (Our Sea), Dubrovnik, Vol. 60, No 1-2, pp. 21-24, ISSN: 0469-6255. 2013.

[16] Rozic, T., Fiolic, M., Bacura, M. The logistics concept of optimized retro-reflection dynamic test of road markings on the roads in the Republic of Croatia. Logi - Scientific Journal on Transport and Logistics, Vol. 3, No. 2, pp. 128 - 135, ISSN 1804-3216. 2012.

[17] Krile, S., Kezić, D., Self-Management Principles in Autonomic Service Architecture Suported with Load Balancing Algorithm, Automatika, Vol. 51., No. 2, pp. 193-204, ISSN: 0005-1144. 2010.