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## The Multi-criteria Decision Support in Choosing the Efficient Location of Warehouses in the Logistic Network

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### Abstract

The warehouse facilities location is a complex multi-objective decision problem. In order to determine this location one can use a different mathematical models that describe the location according to the accepted constraints and criterion functions. This paper presents the warehouses location in the logistic network. The logistic network consists of suppliers, potentially warehouses with the known location and recipients. The variety of constraints that must be considered e.g. the production capacity of suppliers, buyers, the storage capacity makes it difficult to decide on the final location of objects of the logistic network. The warehouse location problem in the logistics network is multi-criteria optimization problem that depends on quantitative and qualitative criteria. In general, the optimization criteria takes the form: minimal storage costs, transition costs of the cargo through warehouse facilities, the cost of cargo transport to the warehouse facility, etc. The complexity of the warehouse location problem dictated by the diversity of constraints and decision variables (e.g. the type of binary decision variables and the real type of variables), the search for the location of many warehouse facilities at the same time, multi-criteria aspects of the problem imposes the need for the application of an appropriate optimization algorithm adequately to the presented location problem. The genetic algorithm is a practical optimisation tool solving many difficult decision problems. It should be underlined that in complicated problems this tool does not guarantee the optimal solution, but sub-optimal. Despite that, the quality of the solution is accepted by decision-makers.

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## 1. The introduction

The problem of warehouses location is an issue that is generally known and widely discussed in the context of decision-making problems forming the logistic network [1, 3, 15]. The main objective in the general warehouses location problem is to find such a location of warehouse facilities that the costs arising from forwarding of a specific volume of goods to the customers via warehouses are as low as possible. The warehouses location problem depends on the complexity of the logistics network. The network structure may be single-level [15] (the direct relationship: suppliers – recipients) or multi-level [2, 6, 17, 10] (the indirect relationship: suppliers – intermediate points – recipients) which is called a hierarchical one.

The warehouse location problem in the logistics network is multi-criteria optimization problem that depends on quantitative and qualitative criteria. In this issue the following criteria may be distinguished [8, 10]: labour costs, transportation costs, storage costs, taxes, labour characteristics: skilled labour and availability of labour force, existence of modes of transportation, quality and reliability of modes of transportation, proximity to customers, suppliers or producers.

The presented criteria emphasise the complexity of the problem arising from location of storage facilities and in a certain way determine the application of the multi-criteria decision-making assistance in selection of the optimum solution [4, 19, 5, 12]. Whereas the warehouses location problem in the logistic network taking into account the one optimization criterion is solved by the use of the genetic algorithm [9, 8] or branch and bound algorithm [1]. In turn multi-criteria decision-making problem of warehouses location is solved by TOPSIS, ELECTRE, Grey Theory methods [20], fuzzy logic [5] or Choquet integral [4].

The main aim of this article is to develop the tool which may be used in the multi-criteria warehouses location problem in the logistic network. In order to solve the multi-criteria warehouses location problem the genetic algorithm was developed. The application of the genetic algorithm in the multi-criteria warehouses location problem was dictated by the fact that the authors do not find the application of this algorithm in the examined multi-criteria problem.

Genetic algorithms belong to a group of heuristic algorithms, which do not guarantee the optimal solution, but only close to the optimal solution so-called sub-optimal. Despite this inconvenience genetic algorithms are a practical tool for optimization and are used in a variety complex decision problems e.g. vehicles routing problems [18, 14, 13]. The complexity of the problem of locating warehouse facilities limits the use of accurate methods to find optimal solutions and allows to accept sub-optimal solutions.

## 2. The warehouses location model

The warehouses location model refers to the logistic network which consists of suppliers, warehouses and production companies – recipients. The suppliers provide different types of the raw material to the production companies in a given working day. The material flow between warehouses is possible. The production companies can store the raw material in own warehouses.

### 2.1. Decision variables

The warehouses location is designated on the basis of the decision variables. The first type of the decision variables determines the volume of the raw material which flows between the facilities in a given working day. On the basis of this volume taking into account constraints and criterion functions the warehouses location is determined. The first type of variable is interpreted as the volume of raw materials which are transported between network points in a given working day.

The second type of decision variable determines the warehouse location and takes the binary form. The variable assumes the value of 1 when the given warehouse belongs to the logistic network of manufacturing plants and 0 if it does not belong to the logistic network.

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