METHODOLOGIC CONDITIONING OF TRANSPORT OPTIMIZATION

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Abstract

Department of Agricultural Machines and Devices has conducted studies upon the improvement of transport organization in agriculture and foodstuff industry for many years. Computer systems for optimization of transporting means for agricultural goods were worked out assuming that the amount and structure of transporting means is well known. To solve the complex problem, the analysis of stuff adherence to loading works, loading issues, optimum utilization of transporting mean and selection of transporting means for a given task should be performed.

The paper presents the method for selection the number and type of transporting means to realize a given transport task. The method was verified for any number of transporting means and any number of receiving points. It required describing and programming the database on transporting means as well as receiving points. Current software version's limitation is considering at the most 4 different transporting mean types. The database gives an opportunity of easy and fast changing or modifying data using professional programming tools. The access to data processed is through properly defined interface. As an effect, software lists a number of all combinations of type and number of transporting means that ensure completing the desired task. The system also gives a simple opportunity to define reserves of transporting power aiming at guaranteeing the transport task in an emergency.

Keywords*: transport, agriculture, optimization of transport, selection of transporting means*

UWARUNKOWANIA METODYCZNE OPTYMALIZACJI PRZEWOZÓW

Streszczenie

W Katedrze Maszyn i Urządzeń Rolniczych Akademii Rolniczej w Lublinie od wielu lat prowadzone są prace, których celem jest poprawienie organizacji pracy przewozów realizowanych w rolnictwie i przemyśle rolno-spożywczym. Opracowano komputerowe systemy optymalizacji pracy środków transportu przemieszczających różne płody rolne, zakładając, że znana jest ilość i struktura taboru używanego do realizacji procesu przewozowego. Chcąc rozwiązać kompleksowo problem przemieszczania ładunków w rolnictwie, należy przeprowadzić analizę przydziału pracowników do prac ładunkowych, rozwiązać zagadnienie załadunku - optymalnego wykorzystania ładowności środka transportu i dokonać doboru środków, które mają być użyte do wykonania zadania przewozowego.

W artykule przedstawiono metodę doboru liczby i typów środków transportu do realizacji określonego zadania przewozowego. Metodę opracowano dla dowolnej liczby typów środków transportu oraz dowolnej liczby punktów odbioru masy towarowej. Realizacja jej wymagała opisania i oprogramowania bazy danych o środkach transportu oraz punktach odbioru masy towarowej. Ograniczeniem obecnej wersji programu jest rozpatrywanie w rozwiązaniu docelowym najwyżej 4 różnych typów środków transportu. Opracowana baza daje możliwość łatwej i szybkiej zmiany bądź modyfikacji danych z wykorzystaniem profesjonalnych narzędzi programistycznych. Dostęp do przetwarzanych danych odbywa się poprzez odpowiednio zdefiniowany interfejs programu. W efekcie program określa liczbę wszystkich kombinacji typów i liczby środków transportu, które zapewniają wykonanie planowanego zadania transportowego. W systemie przewidziano prostą możliwość określania rezerw mocy przewozowej mającej na celu zabezpieczenie wykonania przewozów w przypadkach awaryjnych.

Słowa kluczowe: *transport, rolnictwo, optymalizacja transportu, wybór środków transportu*

1. Introduction

A complex introduction of technical progress in agriculture plays an important role at every stage of production process. The increase of weight of transported agricultural products makes a need to improve the transport organization on a base of comprehensive studies upon the conditions the transporting means would be utilized. Therefore, the farm cannot be equipped only in one type of transporting means. It should have transporting sets meeting both properties of transported goods and cooperation with machines for sowing, harvesting, etc.

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2. Grounds for the issue undertaking

A literature references give detailed and precise methods to solve well defined transporting tasks, in which delivery and receiving points as well as transporting means are well known.

Most of these methods are linear programming that not always are possible to direct use in a case of making transporting tasks and defining the schedule for transporting mean work. There is a lack of methods that would solve not-fully defined transporting issues, e.g. where number and types of transporting means to use is unknown. Such kind of problems are encountered when planning the transporting task that has never been realized or in a case of modernization of transport park at a given company.

Such situation forced to undertake the attempts to work out and verify a generalized method for initial selecting the type and number of transporting means to realize any transport task. A set of solutions permissible in the method must be subsequently subjected to optimization calculations according to an appropriate model of transport task [2].

The paper is aimed at creating the computer system for evaluating the number and type of transporting means to realize a given transport task. Building such system required to work out the algorithm for transporting means selection and then programming it in Delphi language. Correctness of the software was verified using real example.

3. Optimization of loading process

Assignment task

It is a matrix given:

$\mathbf{c} = (\mathbf{c_{ij}})\mathbf{m}\times\mathbf{n}$, $\mathbf{c_{ij}}$ - usefulness of ***i*-th** worker to ***j*-th** work.

Following matrix should be defined $\mathbf{x^* = (x^*_{ij})m}\times\ \mathbf{n} \in \mathbf{\Omega}$, such that:

$$f(x^*) = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^* = \max_{x\in\Omega}\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}, \tag{1}$$

where:

$$\Omega = \left\{ x : \begin{array}{l} \sum_{i=1}^{m} x_{ij} = 1, j = \overline{1,n} \\ \sum_{j=1}^{n} x_{ij} = 1, i = \overline{1,m} \end{array} \; xij \in \{0,1\} \right\}, \tag{2}$$

and:

$$x_{ij} = \begin{cases} 1 \\ 0 \end{cases}, \tag{3}$$

1 – when ***i*-th** worker is assigned to ***j*-th** work, 0 – in other cases.

Thus, the task consists in defining such assignment of workers to works in order to their total usefulness was maximum.

Loading task

There are given:

n – number of loading types,

$\mathbf{a_j}$ – weight of ***j*-th** load $j = \overline{1,n}$,

$\mathbf{c_j}$ – value of ***j*-th** load $j = \overline{1,n}$,

b – capacity of transporting mean.

Not exceeding the capacity, transporting mean should be loaded in such a way in order to weight of the load was maximum. It can be written as follows by defining:

$$\mathbf{x^* = (x^*_1, x^*_2, \ldots, x^*_n) \in \Omega \subset E^n}, \tag{4}$$

such that:

$$f(x^*) = \sum_{j=1}^{n} c_j x_j^* = \max_{x \in \Omega} \sum_{j=1}^{n} c_j x_j \ , \tag{5}$$

where:

$$\Omega = \left\{ x \in E^n : \sum_{j=1}^{n} a_j x_j \le b, x_j \in \{0,1\} \right\}, \tag{6}$$

$$x_j = \begin{cases} 1 \\ 0 \end{cases}, \tag{7}$$

1 – when ***j*-th** load is loaded, 0 – when ***j*-th** load is not loaded.

Other version can be achieved when:

$\mathbf{a_j}$ - weight of the unit of ***j*-th** load type,

$\mathbf{c_j}$ - value of the unit of ***j*-th** load type,

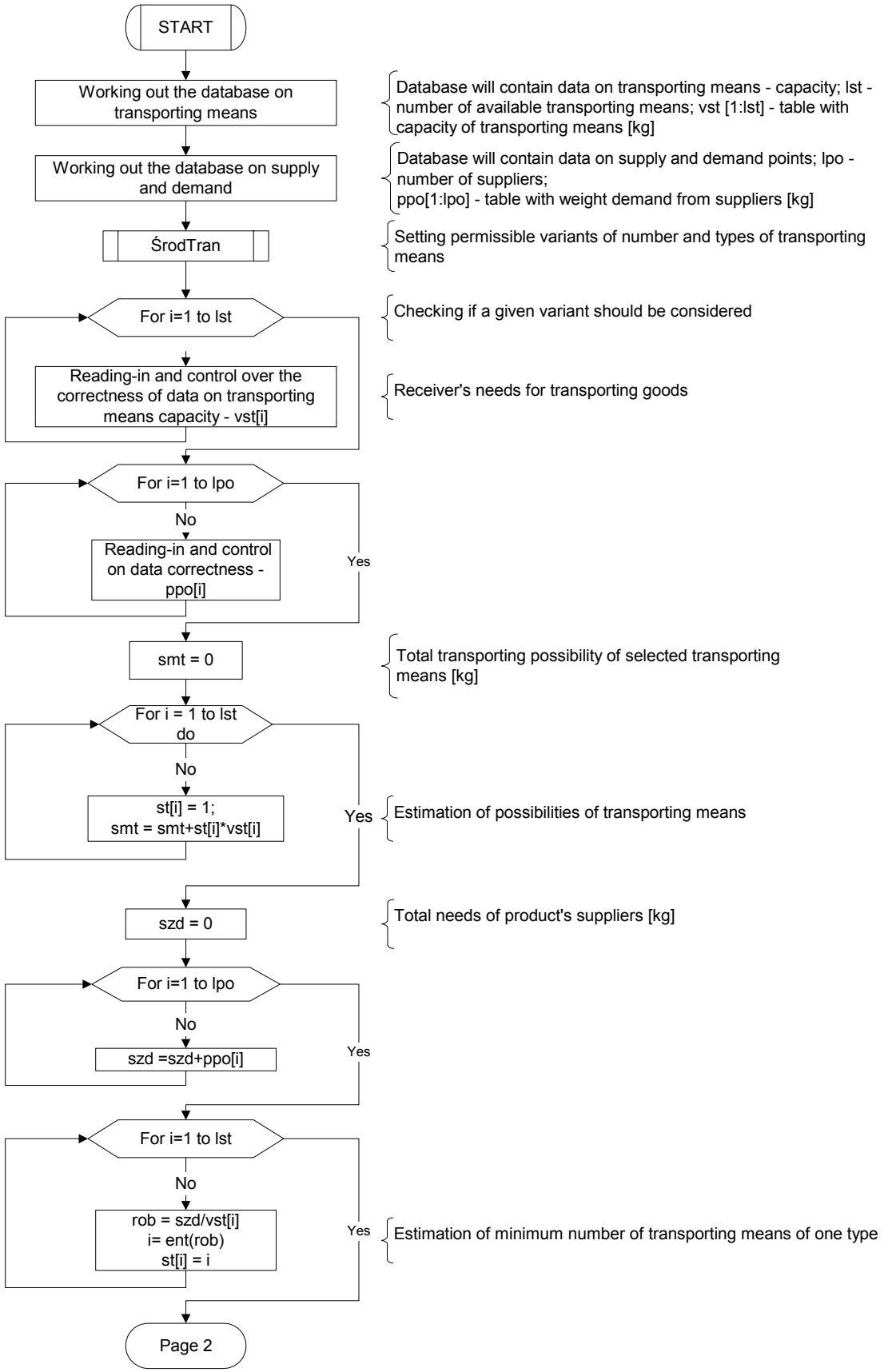
$\mathbf{x_j}$ - number of loaded units of ***j*-th** load type, $\mathbf{x_j \in R}$ [1].

4. Algorithm for transporting means selection

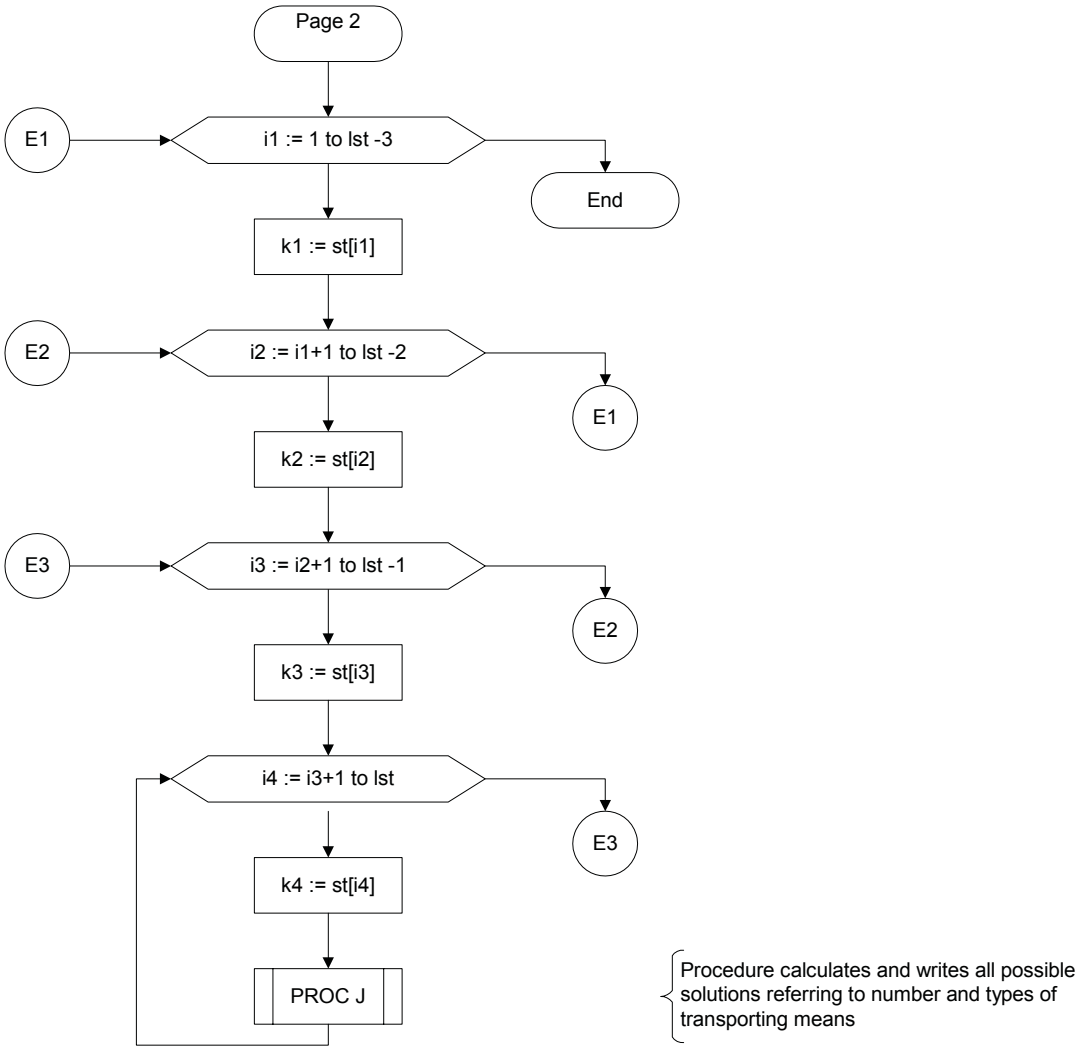
Algorithm describing the procedure aiming at selecting the number and type of transporting means is presented in Figure 1. It was accepted:

lst – number of available transporting mean types,

vst[1..lst] – capacity of transporting mean [kg].



Rys.1. Schemat blokowy algorytmu doboru środków transportowych
Fig. 1. Scheme of the algorithm for transporting means selection



Kontynuacja Rys.1
Continuation of Fig. 1

lpo – number of receiving points,

ppo[1..lpo] – receiver's demand for transported goods [kg],

i, i1, i2, i3, i4, k1, k2, k3, k4, j1, j2, j3, j4 – work indices for programming the loop defining the selection of transporting mean,

st[1..lst] – number of one type transporting means that ensure making the transport task,

smt – indirect variable – total capacity of considered transporting means [kg],

szd – indirect variable – total demand of receiving points [tons].

rob, r1, r2, r3, r4 – work variables used to complete the loop for transporting mean number in case when addition of the following mean is not profitable,

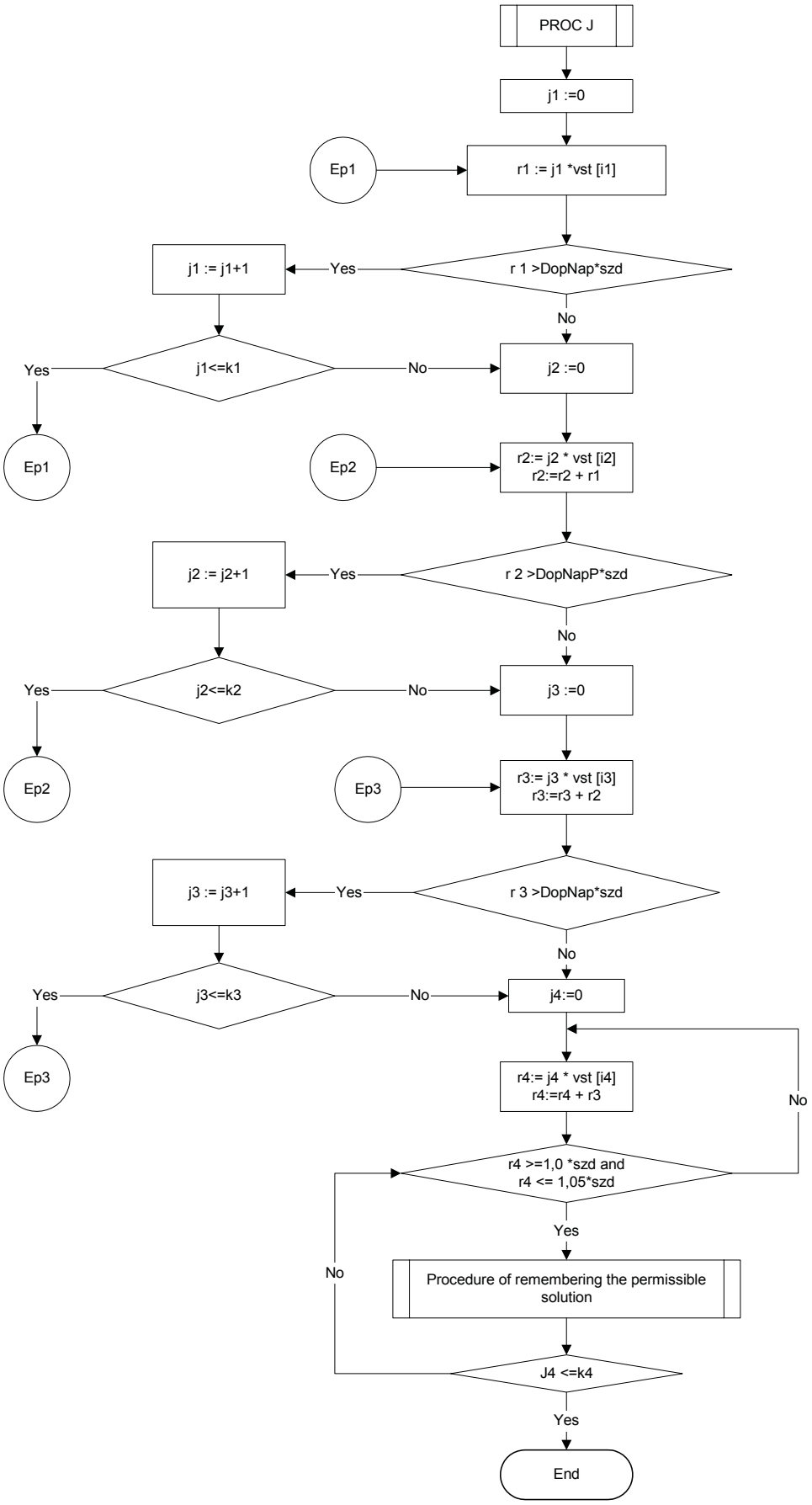
DopNap – program for achieving permissible solutions,

Ep1, Ep2, Ep3, E1, E2, E3 – etiquettes, specific program's fragments.

ŚrodTran – checking if analyzed set of transporting means is able to make the transport task.

Proc J – procedure of remembering the permissible solution.

The program worked out contains 20 procedures that are going to be described in other publications.

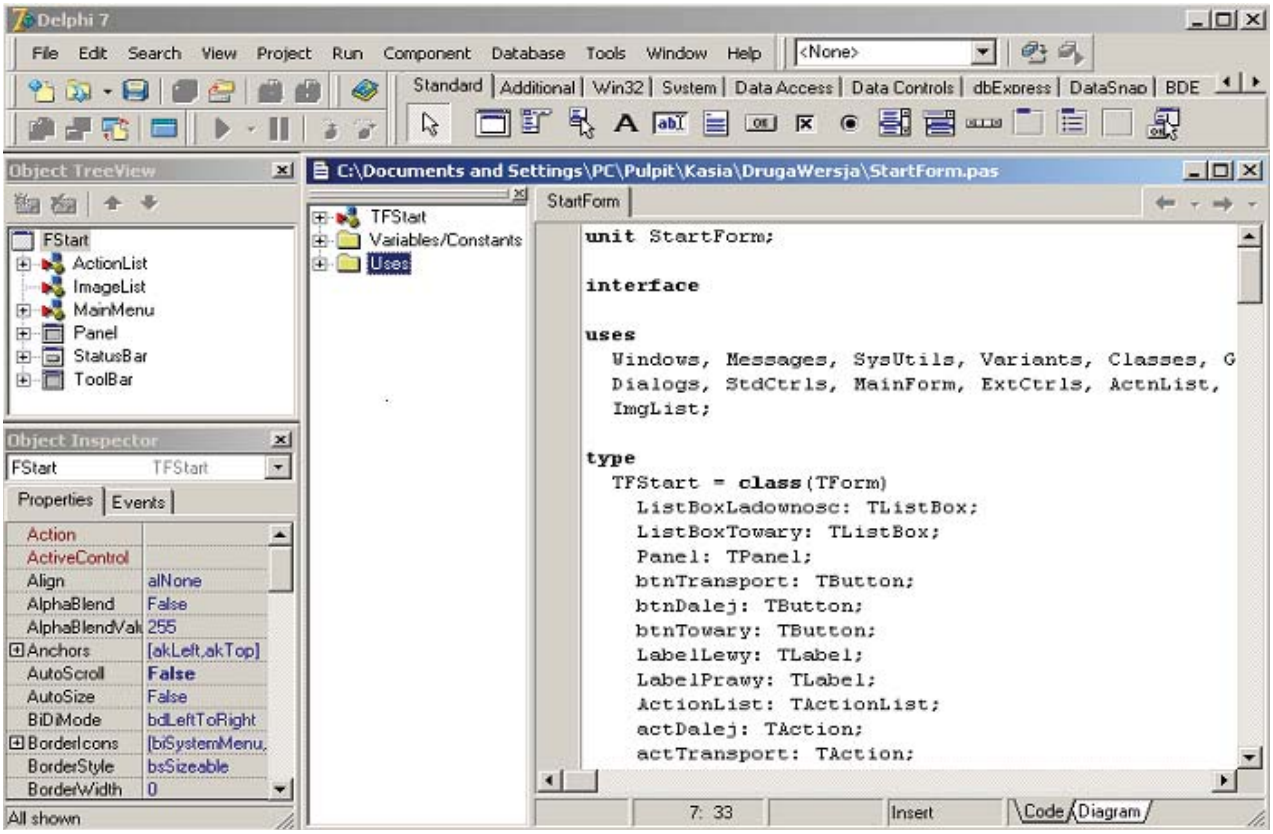


Kontynuacja Rys.1
Continuation of Fig. 1

5. Verification of the system

Prior to system programming, a database on transporting means and receiving points was worked out. The system was written in Delphi language and software was named „Transport".

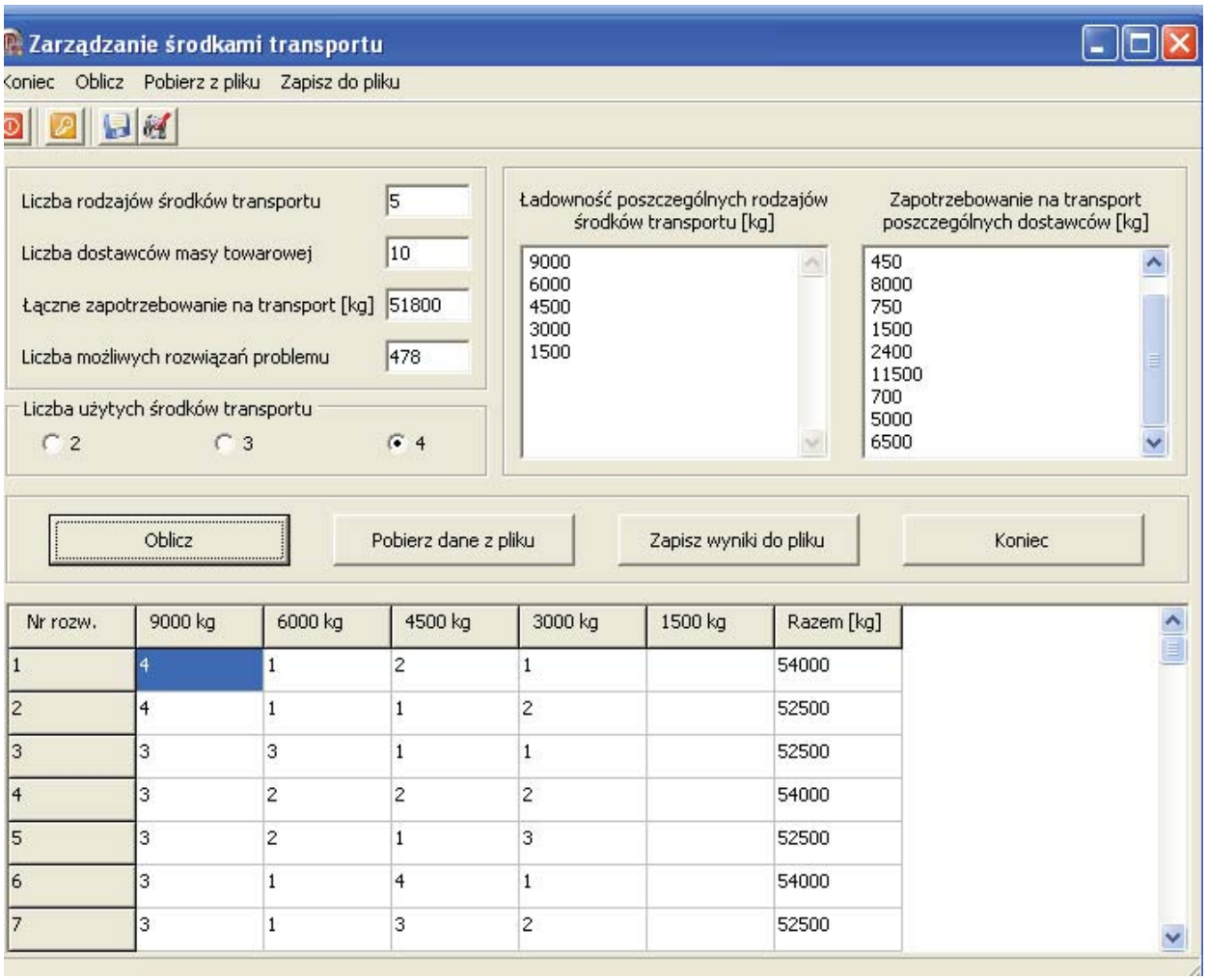
Application of event programming is necessary for applications within Windows environment – programming of events that may occur during application performance. Those events may be generated by the system (activation of application window, application error, dividing by zero) or by user (pushing a key). Main program is constantly ready to catch events and to identify them. A specific event invokes the procedure for its operating (entered by user or generated by compiler), which allows for going to various branches and loops of program execution [3, 4]. The initial fragment of source code for software „Transport" written in Delphi language is presented in Figure 2.



Rys. 2. Fragment kodu programu „Transport" w środowisku Delphi
Fig. 2. Fragment of source code for program „Transport" written in Delphi language

Figure 3 presents resulting form illustrating the window for management of transporting means selection along with result table.

Analysis of the resulting form reveals that 10 suppliers had 51800 kg of goods transported. To realize the transport task, four of five transporting means can be used; their total capacity is given in window „*Ładowność poszczególnych środków transportu*". There are all possible combinations of utilization of available transporting means presented in lower part of the form. Vehicles selected to realize the transport task are taken into account in optimization calculations in accordance to particular purpose function.



Rys. 3. Okno zarządzania wyborem środków transportu
Fig. 3. Window for transporting means selection management

6. Summary and conclusions

The study consisted in working out and programming the method for selecting the transporting means to transport agricultural products. The method was worked out for any type and any number of transporting means as well as any number of receiving points. Presented algorithm describing the procedure aimed at making a selection of number and type of transporting means. The method realization required to describe and program the database on transporting means as well as receiving points. Considering at most four different types of transporting means is the only limitation of the solution.

The database gives an opportunity of easy and fast changing or modifying data using professional programming tools. The access to data processed is through properly defined interface. As an effect, software lists a number of all combinations of type and number of transporting means that ensure completing the desired task. The system also gives a simple opportunity to define reserves of transporting power aiming at guaranteeing the transport task in an emergency.

The method and software allows for drawing following conclusions:

1. It is versatile and makes possible to solve any large transport task.
2. It may be used to solve any transporting task; it is only important to define types and parameters of transporting means as well as receiving network.

8. References

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