Transformation of Knowledge Sources In Decision Support System

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Abstract:
The article presents the organization of information structures for the needs of a complex, multi-faceted (multi-methodical) decision analysis, the subject of which is a certain category of objects. The focus is on the discussion of the transformation of the information structure of partial mathematical models, reflecting the objects of analysis, to the form of records of the database and on their connection into a more complex structure, so-called multi-model, in order to subject the method of multi-criteria optimization to calculations. There was also mentioned the possibility of transformation of these complex structures from data records to a simple, tabular form transferred on the inputs of method: AHP, Electre Tri, econometric analysis and induction of decision rules.

Keywords: *engineering of combining the MLP models, MLP multi-model, computerized decision support system (DSS)*

1. Introduction

The construction of information systems supporting decisions should take into account the idea of spreading methods (knowledge) in the most important moment of the civilization process – the decisive game, which is connected with the selection of the best available solutions. This involves the sharing of complicated methods in a simple and useful form to decision-makers. From the point of view of engineering of information systems, this task is not easy, because decision processes usually concern the future and are not fully predictable. One should also take into account the frequent changes of event structures and things in management, which cause that we are dealing with unstructured situations, unique, and therefore difficult to program.

Literature [3], [7], [8], [12] contains a variety of procedures and methods of multiple criteria decision making (MCDM). According to Greco et al. [7], they can be divided into methods based on the functional model (American school) and relational model (European school). The vast majority of these methods depends on the input data expressed numerically. The remaining group, constituting the complement in this context, are the research methods created on the basis of statistics, artificial intelligence and psychology, in which the numerical parameters characterising the research subject are not specified (phenomenon, object). They are called the non-parametric methods, often there are no assumptions in them as to the completeness or precision of data. This group, for example, includes the symbolic methods of data classification [6] and most of the methods based on the theory of rough sets, applied to the analysis of data consistency, their grouping and induction of decision-making rules [9].

Integration of many complementary methods of decision-making in the information system requires, first of all, the development of such a model of data organization which will be more adjusted to the theory of decision-making. This issue can be formulated in a form of a question. *What notation in the organization of factual resources should be used so that the decision-making situations can be fully described?* Secondly, the integration requires arming of the decision-making analysis process on its each step with computer algorithms of transformation of various data forms in such a way that in the context of the problem there is used one common set of input data (numeric, linguistic or mixed). The consequence of the integration of various quantitative and qualitative methods in one system is engineering based on the interdisciplinary approach, which combines the quantitative and behavioural aspects of decision-making theory in a comprehensive, coherent and useful process of support of decision-making.

The article focuses on a very important, methodical and engineering aspect of the construction of the system supporting decision-making. It is the organization of information structures for the needs of the complex, multi-faceted (multi-methodical) decision analysis, which subject is the particular category of objects. The essence of the problem is the transformation of the information structure of partial mathematical models (identical to objects of decision-making analysis) to the form of database records and their connection into a more complex structure, so-called multi-model, in order to subject the methods of multi-criteria optimization to calculations. There is also the transformation of partial models stored in the form of records to a simple, tabular data structure (e.g. vectors of criteria values) required on the integrated inputs in the method system: AHP (ranking), Electre Tri (grouping), econometric analysis (valuation) and induction of decision rules (the use of rough set theory). A wider context for the thread is the integration of knowledge sources – measurement data, expert opinions, unified structures of mathematical models and collections of selected methods – in the information system, in an important moment for the information and decision-making process, which is the decision-making game. The goal of each game is the selection of the solutions from the best available ones.

2. Attributes and Scope of the System Supporting Decision Making

The functional scope of supporting the decisions was determined as the solving of decisive tasks connected with multi-criteria selection, grouping (sorting) and organising (ranking) of any decision variants, understood as objects of the analysis representing the given category of events or things. These objects must have a uniform information structure. The additional functionality of the system is the analysis and the evaluation *ex post* of the obtained results of the decision-making process. It should be noted that the studies carried out in the system can have the formal nature (official), taking on the form of the legally sanctioned procedure (e.g. public tender, where the offers are evaluated) or less official, cognitive, where the decision maker is repeatedly supported through simulations (e.g. evaluation of employees, products, services, variants of planning, etc.). The fact that the theory of decisions creates methodological foundations for the analysis and generating best solutions is not about the utility of the information system in practice. In fact, the needs of management translate into the essential factors that should be taken into account in the design of system supporting decision-making, namely:

- *multi-stage nature of the decision-making process,*
- *multi-criteria nature,* in which *the structure of criteria is* simple (criteria vector) or complex (hierarchical or network dependencies),
- *number of decision-makers and experts,*
- *scale of the decision problem* (few or mass problems),
- *flexibility of decision variants* (customising the parameter values),
- *linguistics of data* (statements of experts or respondents).

The complexity of the description of the decisive situation causes that it is difficult to emerge the method that would be universal, to which we could attribute the possibility to obtain the best solution of many different decision-making problems.

The discussed system of supporting decision-making is a hybrid solution, which using the engineering techniques of the computer processing of data connects and shares in a simple useful form algorithms of various supplementary and implementing the paradigm of the methods supporting the decisions. The research procedure included in it is performed in three stages, it includes: 1) organization of data, 2) calculations of the decision analysis and 3) presentation of results (Figs. 1 and 2). The intention of the proposed scheme of thought comes from the understanding of the support of decisions as a process, in which based on the fact base (data) we analyse and conclude, and then we make decisions. This takes into account the knowledge of users and most of all of experts, who analyse facts, express their opinions using the ordinal scale of linguistic assessments and use the mapping methods proposed in the system.

Organising data (Fig. 1) as the base of integration of methods there was accepted the coherent and flexible information structure of the system, which was subordinated to the construction of MLP models (Multicriteria Linear Programming). It allows you to define the template for the decision-making task (standard mathematical model, Fig. 1). This construction takes into account the requirements of the decision maker, which relate to the potentially analysed set of objects and they are expressed through: decision variables, limiting conditions, one- or two-level structure of criteria of assessment and the corresponding preferences. According to the template to the system there are introduced data of objects (decision variants: W_1, W_2, ..., W_n). Technical and economic parameters of each variant can be expressed in the form of numerical values and linguistic assessments (fuzzy values) from the ordinal scale defined by experts or respondents. For the optimization calculations all linguistic forms of data must get transformed into numerical values. The basis for the conversion of verbal expressions into numerical (defuzzification) and vice versa (fuzzification) is the methodology of the construction of linguistic quantifiers based on the theory of fuzzy sets. After the introduction and confirmation of data, each variant becomes the record (writing) in the relational database and at the same time is the autonomous, partial mathematical model. The object takes the form of the formalised task of the linear program-

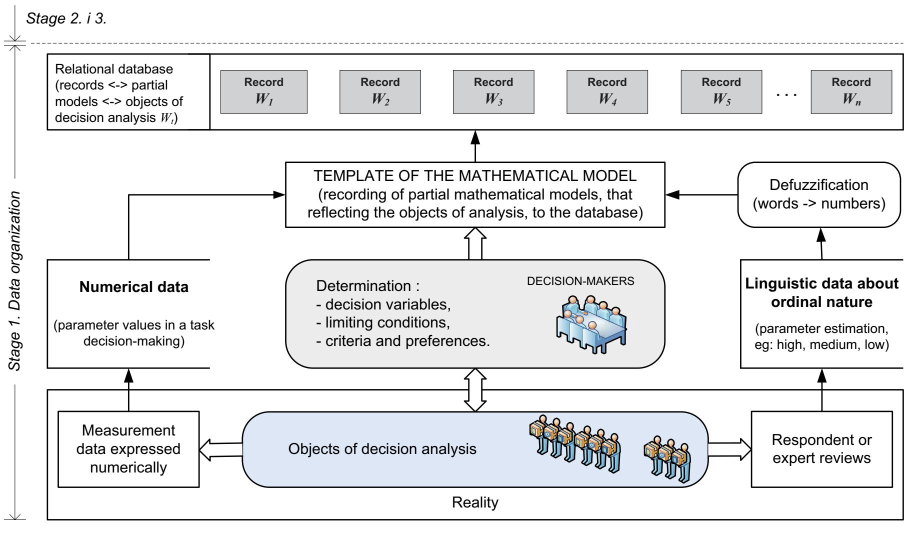


Fig. 1. Organization step of source data in the system supporting decision-making (source: own study)

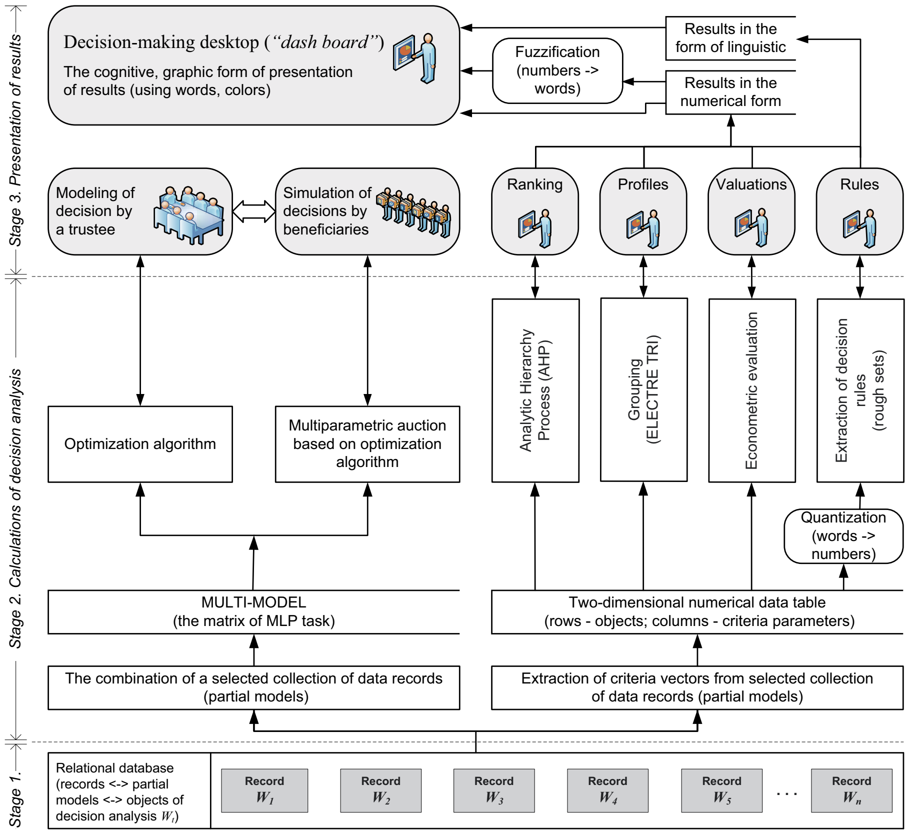


Fig. 2. The scope of multi-faceted (multi-methodical) decision-making analysis of objects in the system supporting decision-making (source: own study)

ming, which after obtaining the positive optimization result (where it is not the contrary system) is saved in the database with the admission status to the stage of decision analysis calculations.

The second stage (Fig. 2) includes the issues of combining data records – partial mathematical models identical to objects of the decision-making analysis – to the form of a multi-model (MLP task matrix) for the needs of the multi-criteria optimization and transformation to the simple, tabular structure of data required on other inputs of the multi-methodical analysis. Integration of methods in the system of supporting decisions consists of the use of their functionality on a common set of data (objects) within a coherent, logical and comprehensive information-decisive process consisting of:

A. *optimization of decisions* – considered from the point of view of interests of the trustee's resources and from the perspective of beneficiaries competing for the resources,
B. *multi-criteria analysis,* in which there were used the approaches: connected with the achievements of the American school (AHP method – Saata 1980), European (ELECTRE TRI – Roy 1991) and Polish school (Rough Set Theory – Pawlak 1982),
C. *identification* in terms of quantitative methods of the econometric analysis.

The third stage (Fig. 2) includes the presentation of detailed results for each method separately and together, in the form of the decision-making desktop *("dash board"),* within which the applied methods (points B and C) function on the basis of a consultation of experts diagnosing the state of the tested objects. The desktop integrates the results of methods supporting decisions in the utility aspect. It is an interactive system enabling the multi-dimensional (multi-methodical) diagnostics of the selected object W_t (or a new one W_{n+1}) against the results of the whole set (W_1, W_2, ..., W_n). It has the cognitive, graphic form of presentation of results of the applied methods. It is a kind of machine graphics, which consolidates the graphic visualization with cognitive processes taking place in the man's mind at the moment of making the decision. The structure of the desktop is based on the premise that knowledge about the object (its rating) expressed by shape and colour is absorbed faster than information in the form of numbers and text.

3. Transformations of Structures Based on the Information Notation of the MLP method (Partial Models ↦ Database Records ↦ Multi-model)

In the studies over the system supporting the decision-making a great attention was paid to the description (formalization) of information conditions of the considered decision situation, on which one can invest many methods of mapping reality and mainly describe almost all components of the decision-making process. The original solution is the construction of the platform of data organization based on the information notation of the MLP method. Defining decision problems (tasks) in the system is inseparable with the determination of the structure of the mathematical model template in the specially developed for this purpose module of the MLP model generator. Its service was divided into thematic groups (blocks) concerning the variables, balances and equations of partial goals and changes of labels (names, units of measurement and character relationships). Adding or removing any element is seen in all blocks. In detail in these groups there were distinguished (Fig. 3):

A. DECISION BLOCK – where we can add or remove decision variables and determine their type: floating point, integer and binary,
B. TASK BLOCK (individual constraints) – in which one can add or remove constraints and balances constituting the internal information structure of all objects W_t,
C. SHARED LIMITATIONS BLOCK – the area, in which one can add or remove constraints and balances

conditioning the selection of objects W_t considered together in the multi-model matrix,

D. CRITERIA BLOCK (partial goals) – the area of adding or removal of equations of partial goals. In each record there are determined the *min/max* relations [1].

Parameters $b^{(t)}_{ij}$, $bb^{(t)}_{i}$, $c^{(t)}_{gj}$, $d^{(t)}_{kj}$ and cc_g, presented in Fig. 3, can take, in the template of the model, the form of constant values or symbols (programming variables), which values are introduced by the proper data forms (index t means that separately for each object W_t).

In the system there was used the approach proposed by Budziński [4], not requiring the determination a priori of the values of goals for implementation , based on the axiom of a "goal game", difference of non-negative quality indicators ($q_k = x_{(z+k)}$) beneficial features and undesirable features ($q_k = -x_{(z+k)}$) for $k = 1,2, ..., r$ and $z = n\times s$. In this method the partial goals (from block D, Fig. 3)

$$\forall W_t \exists x_j^{(t)} \left\{ f_k(\mathbf{x}_j) = \textstyle\sum_{t=1}^{n} d_{kj}^{(t)} x_j^{(t)} \rightarrow (\min \ \vee \ \max) \right\}, \quad (1)$$

where $\mathbf{x}_j = \{x_j^{(1)}, x_j^{(2)}, \dots, x_j^{(n)}\}$, are recorded in the form of balances

$$\forall W_t \exists x_j^{(t)} \left\{ \left(\textstyle\sum_{t=1}^{n} d_{kj}^{(t)} x_j^{(t)}\right) - u_k x_{(z+k)} = 0 \right\}, \quad (2)$$

then their synthesis is performed to the form of the goal function

$$F(q_1, \dots, q_r) = \textstyle\sum_{k=1}^{r} f(q_k) = \sum_{k=1}^{r} w_k q_k \rightarrow \max, \quad (3)$$

where

$$q_k = \begin{cases} x_{(z+k)} & \text{for } f_k(\mathbf{x}_j) \rightarrow \max \\ -x_{(z+k)} & \text{for } f_k(\mathbf{x}_j) \rightarrow \min \end{cases}. \quad (4)$$

While w_1, w_2, ..., w_r are the ranks of validity, preferences of reaching different goals. While u_k are the technical parameters of normalization bringing k partial goals to their equal rank in optimization calculations:

$$u_k = \frac{100 l_k}{\sum_{t=1}^{n} \left| d_{kj}^{(t)} \right|}, \quad (5)$$

where: are the absolute values of technical and economic parameters. They stand in equations of partial goals with j decisive variables, and l_k is the accepted for calculations number of non-zero elements in the k row of partial goals [5].

The explanation of the idea of constructing templates in the *generator of MLP models* is difficult without approximation of its information structures. *The task* in the system supporting decision-making is created by three sets: *dictionary* – description of the logical sentence structure), *data* (data records representing objects in the task) and *validation* – allowed conditions to process data. There was accepted the principle that every object is the partial model and at the same time the data record (with variable lengths from the point of view of various decision tasks), and the whole task formally fulfils the condition of the relational database with its all attributes (*object = data record = partial mathematical model*). Records of the set of *dictionary, data and archives of templates* have identical structures of fields, what greatly simplifies the communication between them. Recalling the task one creates through the inheriting of *template from the archives its dictionary.* All starting model structures MLP come from this place. From the introduced records of the set *data* (that is partial models) we can construct a comprehensive model (multi-model), solve it and obtain the decisive interpretation, in the form of which there can function any objects – variants of the decision-making analysis – e.g.: offers, requests, scenarios and others. In the information system this is performed by an extensive procedure (Fig. 5).

The designed template is subject to feedback verification (*feasibility test*). The algorithm of the system checks its completeness and after substituting testing data it examines its solutions. Then it is transferred in the form of separate blocks to notepad fields (MEMO) of the *archives* set and *dictionary*. *Archives* constitute the assurance for repositories describing various decision tasks considered in the system. In the design phase of a new template you can inherit from the previously proven solutions and develop (adjust) it to own needs. While the set of a *dictionary* (repository)

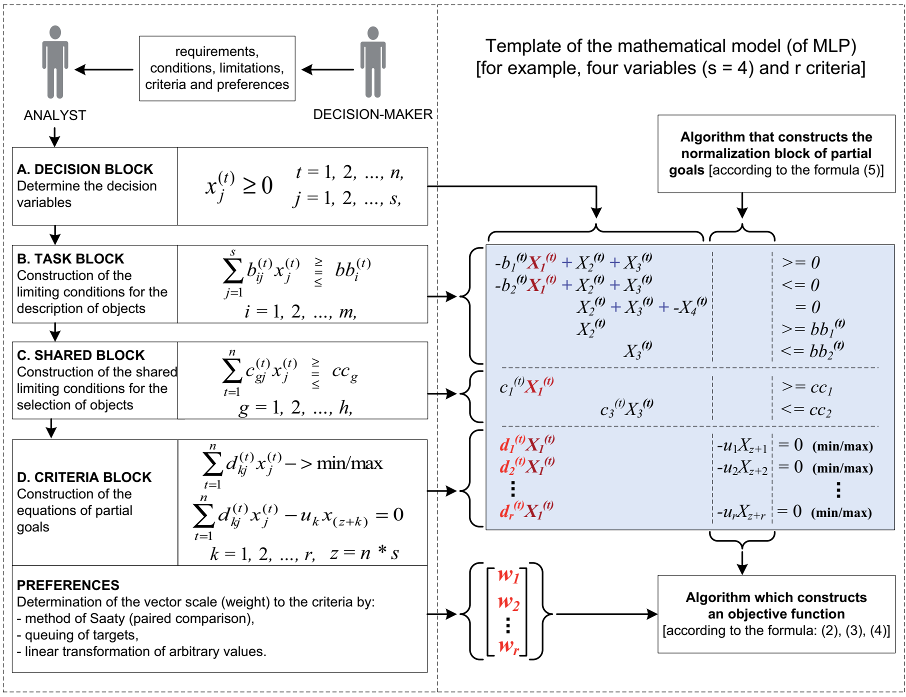


Fig. 3. The idea of constructing a pattern (template) of the mathematical model (source: [2])

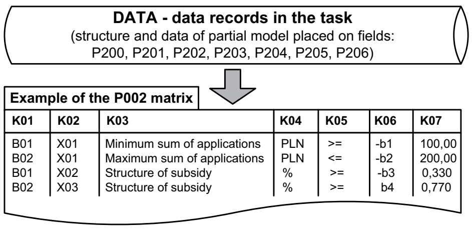


Fig. 4. An example of the information structure of a matrix for parameters of block B (source: own study)

is identified with the specific decision task, it constitutes the main set of meta-data of the task, on which operates the information system after its opening.

Based on the information structure of the *template* algorithms of the system generate forms to introduce data about objects and block structures of partial models with the obtained data, so-called *matrices* (according to Fig. 3, block: A, B, C, D). These structures are registered in the form of records in the table *data* in the fields P200-P206. In Fig. 4 there is illustrated the example of a matrix for parameters of block 'B' (record in the field 'P202'). It is worth mentioning that while adding objects to the system base in records of the table *data* there are only fixed values for parameters included in the template in the form of symbols – programming variables (constant values of parameters are recorded with the template in the set of a *dictionary*).

The next step after the introduction of information about the objects and the generation of matrices is the use of records of data for optimization calculations. In theory, the transformation of structures of the generator is reduced to the connection of the selected records and construction of a multi-model from them. Then, the performance of optimization calculates on it. However, in practice, from the point of view of the algorithmization, using the structures of connected partial models is very complicated. The multi-model is a multiple of variables of the partial model multiplied by the number of objects. A task with hundreds of objects may create a matrix of extremely large dimensions, measured in several thousand variables. In case of the mass data processing (the large number of analysed objects in the task) the algorithmic complexity of calculations may show up in the form of performance problems. Development of the effective solution for processing flexible data structures (models) has become a necessity in this situation.

In the engineering approach there was proposed an original method based on a special structure of meta data, called the *converter,* which is used to connect homogenous in the given task partial mathematical models. Its algorithms build the matrix of the multi-model for the indicated group of objects, regardless of the defined structure of a *template* in the given task, always based on the query of records from the table of *data* and the mentioned file of the *converter*. A thorough explanation is required by the structure of a set of the *converter*, which on one side is the basis for sending the matrix of a multi-model to the module of *solver* (optimising program). While on the other, it accepts the results of calculations and transports them to the proper records of the *data* table.

Converter is identical to the multi-model. It is a table of the relational database, which in its structure contains the full description of the combined records from the *data* table that is partial models (Fig. 5). In the relation between the sets there is a specified system string. Equivalents of the fields of optimization results are found in the structures of records of both tables. The record fields in the file *data,* marked *P101, P102, ..., P199,* are the places, in which there is performed the record of result data transported from

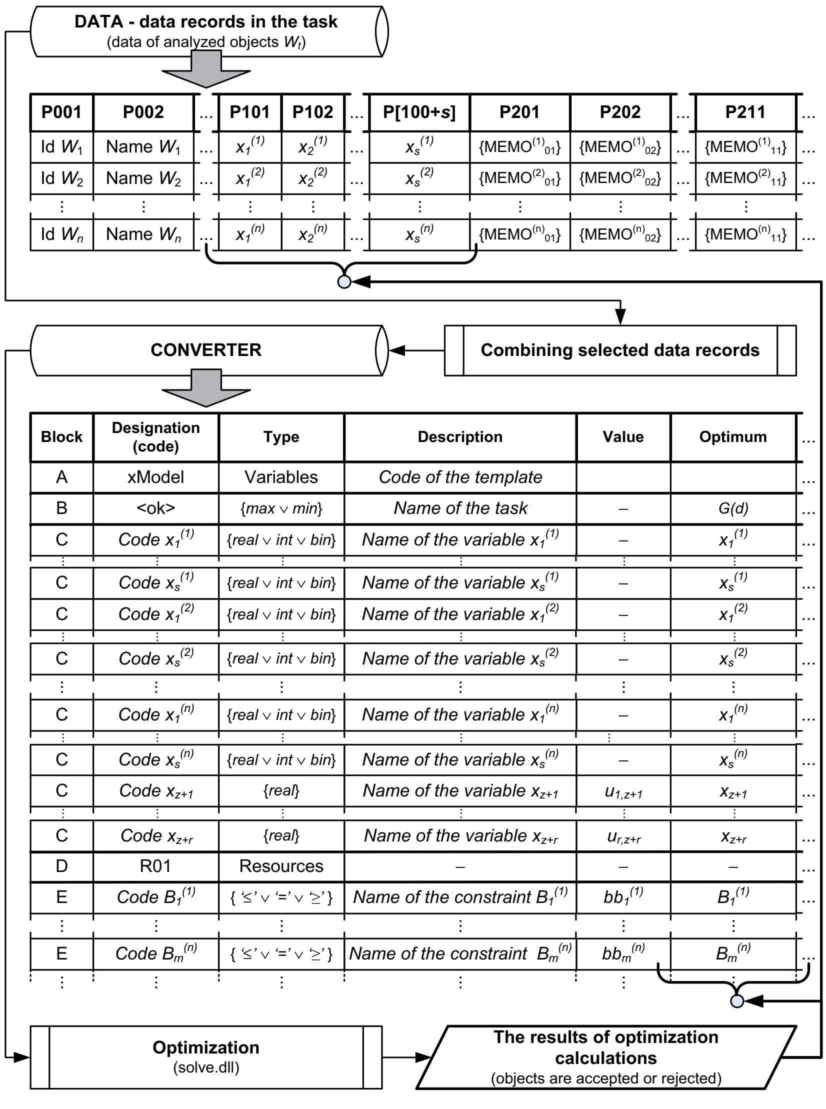
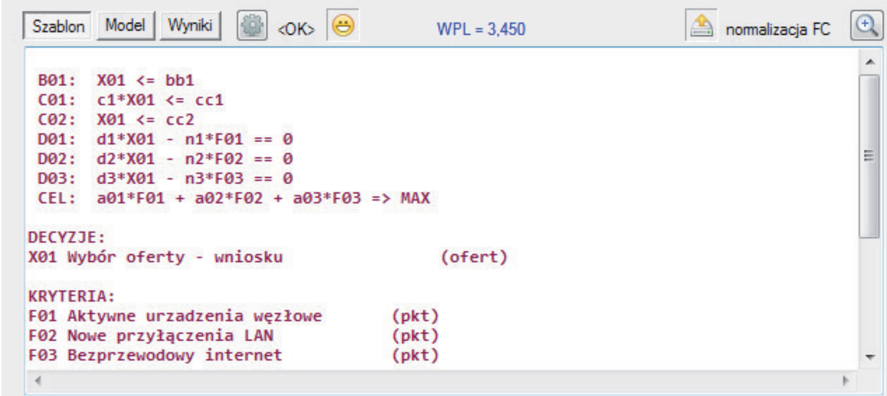


Fig. 5. The procedure of transformation of data records to the matrices of a multi-model (so-called converter) in the system supporting decision-making (source: [2])

the *converter*, from appropriate rows and fields in the column of *optimum*.

Marking the attributes in the *converter* (column layout) have the general nature, are used to represent various components of the block structure of the *template*. These are attributes common for each element of the model: *type, code name, type, description, parameter value, optimum* (and not included in Fig. 5: *evaluation, measurement units*). The column *optimum* is used for storing results from the last optimization. While the *evaluation* depending on the type of the element specified in the row represents: estimation value *ex poste* of partial goal functions, dual prices or unused resources shown by the optimising algorithm.



Screen 1. Decision problem described in the algebraic form – form M1 (source: system DSS 2.0)

The main markings of the converter in the row system result from the category of elements found in the multi-model, there are: 1) decision variables *'x'*, 2) limiting conditions and balances '*B*' and the values of limitations *'bb'*, 3) parameters: *'b'*, *'c'*, *'d'* and goal function (3). In Fig. 5 there is shown a fragment of the row structure of a *converter,* keeping the compatibility of labelling of particular elements with previously accepted formulas in Fig. 3 and: (1), ..., (5).

As a result of optimization of a multi-model there is obtained the division of the considered set of objects into the *accepted and rejected* (Fig. 5). In the first winning group there are variants for which the value of utility functions reaches maximum and at the same time satisfies all limiting conditions determined in the task. The procedure of searching the best set of objects (optimal from the point of view of values of criteria and preferences included in the goal function) begins from the determination by the user of a set of data records for the study. Then the system starts the process of *combining data records* (transposition of result fields, decomposition of matrices) in the set of a *converter*. Thus obtained structure of record of the contents of a *multi-model* allows in a simple and quick way to prepare data in the LPS format for simplex calculations. In return, it accepts the results of optimising results from the *solver* module. Then, the system transfers them to data records, from which this structure was formed.

4. Transformations of Information Structures of MLP Models on the Practical Example

Let us consider the issue of transformations of decision models and functionality of the sub-system of the generator of MLP models on a practical example of the problem of distribution of financial resources on the development of information technology among many beneficiaries W_t (t = 1, 2, ..., n), for which in the model template there were defined binary variables X01 (x_j, j = 1; in the record of the model's pattern the t index was omitted on purpose). Financial needs of the applicants were specified in the form of their assigned parameters c1 (c_{gj}) and limited with a resource common for all cc1 ($c_{gj}x_j \le cc_g$, j = 1, g = 1). It was also assumed that there should be determined the specified number of applications, limited by cc2 ($c_{gj}x_j \le cc_g$, c_{gj} = 1, j = 1, g = 2). The variable X01 was assigned with three quality indicators: d1 – active node device, d2 – new LAN connections and d3 – wireless Internet. They were incorporated in the form of suitable equations: D01, D02, D03 ($d_{kj}x_j - x_{z+k} = dd_k$, where: $dd_k = 0$, $z = j = 1$, k = 1, 2, 3), in which the additional variables: F01, F02 and F03 (x_{z+k} with a slightly changed notation) were brought to the utility function and subjected to maximization (screen 1, form M1).

The construction of the standardised decision task for many beneficiaries should be started by mapping the algebraic form, in which the described reality should be transferred. The MLP task with the utility function is nothing else but a set of equations and inequalities of the first degree, from which one is the function of goal and is subject to optimization (maximization). In this notation one can distinguish 3 groups of constraints: B_i – local, C_g – common and D_k – criteria and the goal function – GOAL (screen 1, form M1), analogous to the formula in Fig. 3 and: (1), ..., (5).

In the model there may be many additional constraints of the C_g type (block C; e.g. value cc_2 is common for the whole task, i.e. the maximum of the number of the selected applications, e.g. cc_2=5 of the best from the general number of the introduced ones). In the system they are called 'OZM' (limitations of model's resources). If we assume for this type of balances a relation „>= 0" ($c_{gj}x_j \ge cc_g$, where: $cc_g = 0$), then such limitations, which have no significant meaning for the optimization process may be a lot. As it was assumed that they can be very useful in further developments of the system. Parameters c_{gj} found in every inequality of the C block may function as vectors of decision attributes in the applications of the approximate rough set theory and dependent variables in the econometric analysis. They are used, respectively, towards the condition attributes or independent variables, which role is fulfilled by the vectors of criteria parameters d_{kj} (block D).

The complementation of the presented functionality is the possibility to introduce in the B block, for lo-

SZABLON [DSS004_CA0010]

ID	BILANSE	JM	X01_Wybór	F01_Akty...	F02_Now...	F03_Bezpr...	R	WO
B01	¤Zgodność z celami dota...	pkt	1,000				<=	bb1
C01	¤Możliwa suma dotacji cel...	tys.z	c1				<=	cc1
C02	Wnioski najlepsze	W-ski	1,000				<=	cc2
D01 ...	Aktywne urzadzenia węzł...	pkt	d1	-n1			==	0
D02 ...	Nowe przyłączenia LAN ...	pkt	d2		-n2		==	0
D03 ...	Bezprzewodowy internet ...	pkt	d3			-n3	==	0
CEL ...	FUNKCJA WPL ...			a01	a02	a03	=>	MAX

Screen 2. Template of the decision-making task in the simplex table – form M2 (source: system DSS 2.0)

MODEL [DSS004_CA0005]

ID	BILANSE	JM	X01_Wybór	F01_Akty...	F02_Now...	F03_Bezpr...	R	WO
B01	¤Zgodność z celami ...	pkt	1,000				<=	1,000
C01	¤Możliwa suma dotac...	tys.z	4703,136				<=	6250,500
C02	Wnioski najlepsze	W-ski	1,000				<=	5,000
D01	Aktywne urzadzenia ...	pkt	9,471	-1,000			==	0,000
D02	Nowe przyłączenia L...	pkt	0,347		-1,000		==	0,000
D03	Bezprzewodowy inter...	pkt	0,085			-1,000	==	0,000
CEL	FUNKCJA WPL			0,667	0,333	0,000	=>	MAX

Screen 3. Simplex model for one object (request) – form M3 (source: system DSS 2.0)

cal limitations of the binary type, markings "¤". They activate the multi-stage nature of the decision-making procedure. This means the use of the function of the system timer function, which is defined by the user in order to obtain binary value "on its output" {0; 1}. This action comes down to the construction of the formula that contains any logical conditions and arithmetic operations, which converts the input value ocn^* for the given parameter $p^* \in \{, , , cc_g, , dd_k\}$ and for each object of the analysis W_t (t = 1, 2, ..., n), for the output scope, required in the MLP task. In the considered example p^* = bb1, it takes the value of bb1 = 1 if the total note $ocn_{\mathrm{bb1}} \in (0; 1)$ which the given application obtained from experts exceeds the threshold of 50%, otherwise p^* = 0. The formula in the programming system will then take on the following form 'bb1 := $if(ocn_{\mathrm{bb1}} > 0{,}5; 1; 0)$'. The value bb1 = 0 for the constraint 'B01: x01 <= bb1' means the exclusion of the offer, application or another decision problem from the set of feasible solutions. Decision-making procedure ends for the given W_t at the formal stage (pre-qualification), i.e. the constraint value bb1 = 0 does not allows the record of such request for further processing in the system.

The algebraic record of decision tasks (form M1, screen 1) becomes complicated, incomprehensible and not too useful in the situation of designing large, complex structures. A good solution is transporting this record to the form of a simplex table. The idea of this form of presentation is that the names of variables are excluded from equations and inequalities and transferred to the header (there is created the description of decision variables). It can be noticed that the presented table on screen 2 (TEMPLATE – form M2), in a clearer way reflects the considered reality than the algebraic equations.

The created decision-making tasks in the form of a template should be equipped with the real values taken from the measurements or from the verbal expressions (linguistic evaluations) of the experts. In the information system this involves transporting data from the relevant record of the relational database (representing the object Wt) to the form of a partial model (MODEL – form M3, screen 3). Each parameter specified in the template in the symbolic form was attributed with numerical values. It should be noted that in case of excluding the transitive procedure introducing the values of standardization parameters (Fig. 3, marking u_k) in place of their symbols, in the system these are: n1, n2 and n3, there is substituted the value 1, leaving the difference sign '-' without changes.

The form of a task of division of the financial resources for the development of information technology can be developed, when within the limitation B01, i.e. the formal binary condition, one demands the fulfilment of some collection of partial goals. It was decided that the proposal in 2/3 should meet the conditions: B02 – *equity of the goal,* B03 – *referring to the area of the school* and B04 – *having features of permanent investment*. Parameters found in them: b02, b03 and b04 will be determined in percentages (screen 4, form M4). While it was assumed that the lack of fulfilment of the formal condition excludes the proposal from further proceedings. The effect of the development of the task is the creation of the manipulation variable x02 and three local variables: x03, x04, x05, referring to the suitable balance limitations: bb1, bb2 and bb3, which sum cannot be lower than 2/3 of the variable value x01. While the assumption about the need to satisfy all three additional conditions are performed by limitations: B06, B07 and B08. If in one of the conditions: B02, B03, B04 the limiting value: bb_1, bb_2 or bb_3 gets the value of 0, the main variable x01 will also not get into the solution, will be equal 0.

In summary, the template of the form M1 and M2 is an ancestor for subsequent model expansions. It was assumed that one model (template M2 or partial model M3) corresponds to one record. In the area of this record there were specified unlimited in size text boxes (so-called MEMO), in which there were written matrices for the data groups. A solution was achieved, in which the template form of a model was transformed into the record of the database, also called a dictionary. This record is a methodical model for other solutions in the system. Its form is automatically placed in the archives of model templates. Each time based on a dictionary there are generated structures for new objects of the analysis (requests) and after the introduction of data to the forms they are recorded also as rows (records) in a separate table of the relational base. The record of the parameters of the partial model in the notepad fields (MEMO) of one record is the basis for its quick transformation into the form of a simplex matrix, performance of optimization calculations and creation of the result edition.

Structures of data in the MEMO fields in reality are the two-dimensional tables recorded in the text form. Their activation to the form of array variables takes place using macro-substitution technology. For transformation purposes there were developed two programming functions. The first one replaces the table of variables into one text string and places it in the MEMO field, while the second function restores the text to the original form of the table of the specified type of variables. The presented way of proceeding allows the: inheritance of identical parameters by the newly introduced objects (requests, decision problems) to the set of source data and enables the standardization of the edition of the process of their introduction (this especially applies to validation).

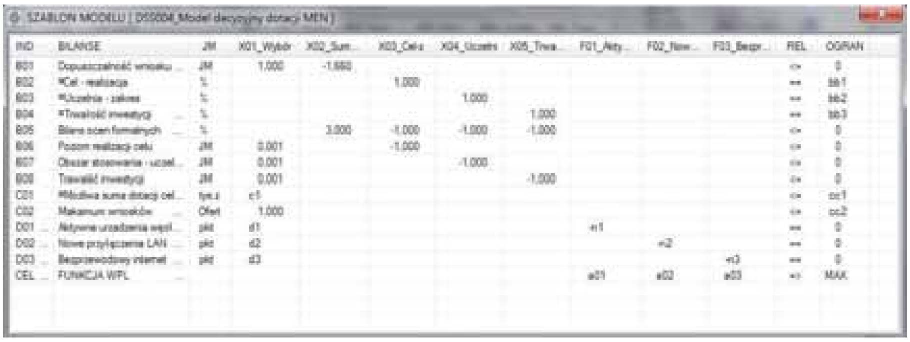
In case of transformation of many records representing objects (of the arbitrarily selected collection of requests) there is constructed the matrix of a multi-model. Autonomous for the partial models limiting conditions B01, …, B08 are assembled together, creating a diagonal matrix of technical and economic factors. On the level of blocks of common conditions C01 and C02 and criteria parameters D01, …, D03 are found in the horizontal system. These structures are repeated. They only differ in values of parameters standing by the specified variables. What is common are only the values of constraints: cc1, cc2 and criteria equations: dd1, dd2, dd3 (screen 5).

An important role in the construction of the models plays the applied numbering of decision variables (e.g. 'X001_X01') and limiting conditions (e.g. 'Y001_B01'). There was accepted the notation with double coding where the first part of the record 'X00*t*_' or 'Y00*t*' means the affiliation to the particular object W_t (at the same time record), and its second fragment is the identification within its area, e.g.: '_X0*j*', '_F0*k*' for variables or '_B0*i*', '_C0g', '_D0*k*' for conditions. This means that each partial model (object) can be described using 99 variables and 99 limiting conditions in each block (B, C and D). In total there can be processed t_{max} = 999 objects, what when multiplied by the maximum number of decision variables in partial models j_{max} = 99 and adding the theoretical number of auxiliary variables k_{max} = 99 found in equations of block D (in practice $k_{max} \leq 11$), gives the upper limit of 99 thousand of variables in the matrix of a multi-code. Explanations are needed by the fact that the optimization is performed using the external package (library DLL – *LPSolveIDE-5.5.0.15*), and the maximum size of the model allowed expressed by the number of variables depends on the purchased licence.

5. Summary

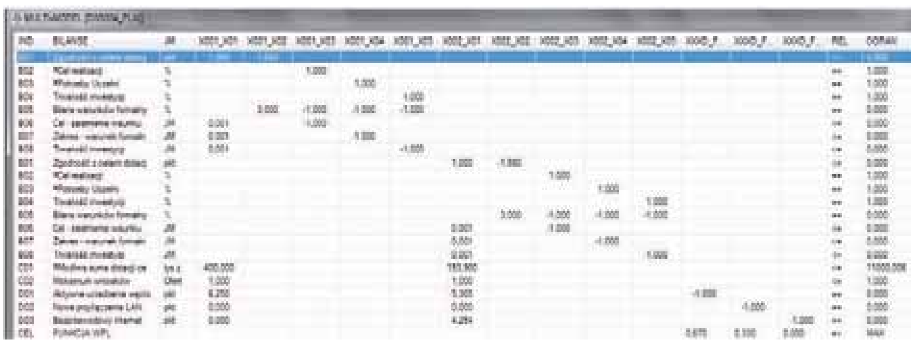
The original information platform, developed within the construction of the system supporting decision-making (modelled on the MLP modelling) provides a comprehensive description of decision-making problems. In the construction of the information technology system supporting decision-making it was assumed that the partial model is associated with the analysed object (decision variant) and at the same time with the record in the table of the relational database. Each data record (object record) is created on the basis of previously designed template (template for the task in a simplex form). After substitution of object data to the template one obtains the relatively isolated decision model.

The developed technology of transformation of database records to matrices of partial models allows the automated connection of any collection to the form of a multi-model of the MLP task. The adopted formalization of data also allows the automatic formulation of structures deviating from MLP models and recalling solutions of other methods of interpretation. As a result, one can at-



IND	BILANSE	JM	X01_Wybór	X02_Sum...	X03_Cel...	X04_Uczeln...	X05_Trwa...	F01_Akty...	F02_Now...	F03_Bezpr...	REL	OGRAN
B01	Dopuszczalność wniosku ...	JM	1.000	-1.000							<=	0
B02	*Cel - realizacja	%			1.000						==	bb1
B03	*Uczelnia - zakres	%				1.000					==	bb2
B04	*Trwałość inwestycji ...	%					1.000				==	bb3
B05	Bilans ocen formalnych ...	%		3.000	-1.000	-1.000	-1.000				<=	0
B06	Poziom realizacji celu	JM	0.001		-1.000						<=	0
B07	Obszar stosowania - uczel...	JM	0.001			-1.000					<=	0
B08	Trwałość inwestycji	JM	0.001				-1.000				<=	0
C01	*Możliwa suma dotacji cel...	tys.zł	c1								<=	cc1
C02	Maksimum wniosków ...	Ofert	1.000								<=	cc2
D01 ...	Aktywne urządzenia wspó...	pkt	d1					-t1			==	0
D02 ...	Nowe przyłączenia LAN ...	pkt	d2						-t2		==	0
D03 ...	Bezprzewodowy internet ...	pkt	d3							-t3	==	0
CEL ...	FUNKCJA WPL ...							a01	a02	a03	=>	MAX

Screen 4. Template of the decision-making task with a complex structure – form M4. (source: system DSS 2.0)



Screen 5. Simplex multi-model for many objects (source: system DSS 2.0)

tempt on this base (data) to connect methods as new mapping hybrids.

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