INTELLIGENT SYSTEM FOR STRATEGIC DECISIONS

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ABSTRACT

The authors assume that today's theory and practice bring tools of managerial decision-making in line with group methods. The article gives a description of the developed intelligent system to support strategic decision-making processes under conditions of uncertainty and risk. Its mathematical core is shown using a variety of methods of analysis, as well as of assessment of preferences on the basis of multicriteria choice and of given set of alternative decisions. The system can be used to solve a wide range of tasks in the field of analytical forecasting and planning of transport infrastructure development.

ENGLISH SUMMARY

Background. *There are many computer programs that implement different methods of decision making. Overview of software products showed (Table 1), that some of them are more versatile and allow conducting evaluation in a variety of ways (Web-HIPRE, Logical Decisions, etc.), while others are soft shells and provide analytics with tools for creation and optimization of high-grade expert systems (FuzzyTECH). However, the integration of decision-support tools in the control loops, and enterprise information systems requires solving a number of problems, which are caused by the following factors:*

- *predominantly collective nature of decision-making activities;*
- *asynchronous flow of individual processes in coordination process;*
- *sharing common data warehouses of enterprise information system;*
- *duplication of information and the emergence of contradictions in databases and knowledge bases of different decision-making methods;*
- *lack of experience in choosing the right decision-support tools for the user.*

The vast majority of application systems are oriented to support the process of individual decision-making. At the same time, the work of experts and decision-makers (hereinafter-DM) in the groups has long been a standard. At the same time the practice of simultaneous presence of experts in large groups is gradually being replaced by asynchronous communication via network technologies. Such an option removes a number of temporal and spatial constraints, and in some cases saves financial resources of the company. Tools of decision-making theory are consistently brought in line with group methods and are designed for different types of tasks. However, the wide availability (including among inexperienced users) generates a problem of selecting an optimal set of mathematical methods and software tools for the implementation of an integrated intelligent decision support system (hereinafter-DSS).

Mathematical core of such a system involves the use of certain methods of decision theory.

Objective. *The objective of the authors is to provide information on intelligent system to support strategic decision- making process.*

Methods. *The authors use descriptive method, the method of analysis and the methods of decision theory.*

Results.

Methods of analysis of networks and hierarchies

Both indicated methods belong to the class of multi-criteria methods and are used under conditions of uncertainty. The method of network analysis (MNA) is a generalization of the method of hierarchy analysis (MHA) for network structures with feedback. This allows acting with mutual dependence criteria by preference. MHA can be used when the elements of a model are independent. For these approaches, a clear graphical representation of the problem of choice is characteristic because of the decomposition of the latter into the components (target, policy, factors, actors, alternative, etc.). Another advantage is the way of preference revelation through pairwise comparisons.

Implementation of the method of network analysis includes the following basic steps:

1. ***Construction of the network structure.*** *To do this, the elements of decision- making tasks are clustered, and arbitrary links between clusters are allowed. Formation of clusters and links is considered as informal procedure and is carried out by experts and DM on the basis of knowledge about the specifics of the problem being solved. Combining elements into clusters helps to reduce the dimension of the model and improve the consistency of judgments. The network shows the impact of clusters on each other as far as an achievement of a global goal is concerned. Benefits, costs, opportunities, risks, and so on could be considered as that goal.*

2. For a network ***a binary impact matrix*** *is built:*

$$B = \{b_{ij}\} = \begin{cases} 1, & \text{if } i \text{ depends on } j \\ 0, & \text{otherwise.} \end{cases}$$

Matrix B is checked for transitivity. If check is negative a network should be corrected. To normalize a network reachability matrix is used, which is obtained by raising a matrix (E + B) into integer powers k until the condition is fulfilled $(E+B)^k \cong (E+B)^{k+1}$*, where E is unity matrix.*

3. ***Prioritization of cluster elements.*** *The elements of each cluster are compared in pairs with respect to each element of a cluster affecting it. In this case, experts estimate the intensity of the influence of some elements on the other. The results of the comparison are entered into the matrix of pairwise comparisons (hereinafter-MPC). Principal eigenvectors of MPC are interpreted as vectors of priorities of compared elements.*

4. On the basis of the matrix B and the calculated vectors of priorities of cluster elements ***a supermatrix of network task W*** *is built. Its columns are formed by major eigenvectors of MPC.*

5. ***Prioritization of clusters based on pairwise comparisons.*** *Comparison of clusters is carried out as described in paragraph 3, or with respect to only a specified purpose or set of elements of a special management hierarchy, which details the main*

Table 1

Applications and software environment to automate the development and use of multicriteria decision-making methods

Software product	Producer	Scope of application
FuziCalc	FuziWare	Software environment focused on spreadsheets and financial applications. Implements an approach based on fuzzy sets.
Fuzzy TECH	Inform Software	Software environment for the design of fuzzy inference.
Business- forecast	Tora – Infocenter (distributor)	Evaluative calculations of the outcomes of management decisions, presented in the form of trees.
Logical Decisions	Logical Decisions	Multi-criteria assessment of alternatives using the method of hierarchy analysis (MHA) or multicriteria utility theory.
WINPRE	Helsinki University of Technology	Choice of alternatives under conditions of incomplete information by decision trees and MHA.
Web-HIPRE	Helsinki University of Technology	Package for general use (implemented in Internet technologies), supporting collaborative decision-making by methods SMART, AHP, MAUT.
Super Decisions	Expert Choice, Inc.	Choice of alternatives, resource allocation, project management in the conditions of mutual dependence criteria and alternatives by the method of network analysis (MNA).
Expert Choice	Expert Choice, Inc.	Resource allocation, project management, using MHA.
PRIME Decisions	Helsinki University of Technology	Evaluation and selection of alternatives in case of fuzzy initial information. Uses decision trees.
ELECTRE III–TRI	University Paris-Dauphine	Multi-criteria selection, ranking and classification of alternatives by ELECTRE methods.

goal (in the second case, a set of supermatrices for elements of managing hierarchy is formed).

*6. **Bringing a supermatrix (or some of them) to a stochastic form by rationing.** To do this, the priorities of cluster elements are multiplied by the priorities of the clusters.*

*7. **Analysis of the structure of the supermatrix and the choice of method for calculating marginal priorities.** For a primitive stochastic supermatrix marginal priorities are calculated as*

$$W^{\infty} = \lim_{k \to \infty} W^{k}.$$

*8. **If the main purpose is detailed by hierarchy, contraction of derived vectors of priorities is carried out.***

The calculated values of marginal priorities are interpreted as the contribution of the corresponding elements in the main goal for a certain period of prediction (until expressed preferences change). Solution of networking tasks enables to come reasonably to the problem of determining the importance of the criteria in the choice tasks. In particular, the sum of marginal priorities of cluster elements shows the extent of the combined effect of the latter (the contribution to the main goal).

Obviously, the result of the analysis is essentially dependent on the reliability and consistency of expert assessments. Therefore, the steps of filling the matrix of pairwise comparisons and clusters are key. In these approaches tools to assess the homogeneity of expert judgments are provided.

When filling MPC an expert answers to the following questions: «Which of two elements being compared is more important or has greater impact?», «Which of two elements being compared is more probable?», «Which of two elements being compared is more preferable?», and «What is this preference?»

Comparison of criteria usually involves comparing their degree of importance regarding the purpose of the study. It is also taken into account, which of the alternatives is more preferable, or more probable on a particular criterion, as well as to which extent one object is more preferable than another.

After filling each MPC, verification of transitivity and uniformity of judgment and calculation of the vector of priorities for elements- «childs» in relation to the element- «parent» is conducted.

PRIME method

The main function of the method (Preference Ratios In Multiattribute Evaluation) is that, unlike MHA or fuzzy inference, information about preferences can be set using intervals.

Sometimes DM does not know the exact count of his own preferences or extraction of the exact values is too complicated and time consuming. In such situations, it is possible to use the inaccurate value judgments in the form of intervals. With their help the weights of criteria and levels of attributes of alternatives are determined. After analyzing, not single assessments, but their possible ranges are appointed for alternatives. Search for the best solution is carried out through a set of decision rules or dominant analysis. Inaccurate value judgments are quite suitable for group decision-making. Individual opinions of different actors can be combined by constructing unified interval estimates from private estimates.

The characteristic features of PRIME method are:

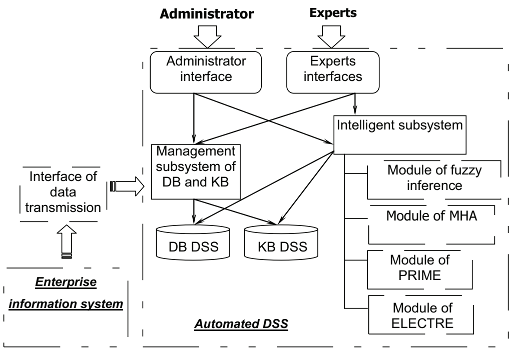
- *use of the difference of attribute values for the establishment of an order of alternatives preference;*
- *refusal to use numerical measurement scales;*
- *representation of preference relations of DM in the form of precise and imprecise assessments, as well as a direct comparison of the alternatives in relation to objectives (holistic comparisons).*

Then the authors consider the fundamentals of the method.

The evaluation function of the additive nature has a form:

$$V(x)=\sum_{i=1}^{N} w_i v_i^N(x_i)=\sum_{i=1}^{N} v_i(x_i),$$

where N is a number of attributes in the hierarchy of a problem, x_i – value of an attribute X_i of the alternative, $v_i(x_i) = w_i{}^*v^N_i(x_i)$ – normalized weighted



Pic. 1. Architecture of the automated decision support system of the enterprise.

value corresponding to the value of x_i.

Let x_i^* and x_i^0 denote the best and the worst values obtained by the attribute X_i. For a normalized evaluation function we have:

$$\begin{cases} v_i^N(x_i^0)=0 \\ v_i^N(x_i^*)=1 \end{cases}.$$

In the assumption that $v_i(x_i^0)=0$, the overall evaluation can be expressed in the form:

$$V(x)=\sum_{i=1}^{N} v_i(x_i)=$$

$$\sum_{i=1}^{N}[v_i(x_i^*)-v_i(x_i^0)]\left[\frac{v_i(x_i)-v_i(x_i^0)}{v_i(x_i^*)-v_i(x_i^0)}\right]=$$

$$=\sum_{i=1}^{N} w_i v_i^N(x_i).$$

Then it becomes possible to express the weights of attributes and normalized evaluation function using the difference in values:

$$w_i=v_i(x_i^*)-v_i(x_i^0),$$

$$v_i^N(x_i)=\frac{v_i(x_i)-v_i(x_i^0)}{v_i(x_i^*)-v_i(x_i^0)}=\frac{v_i(x_i)-v_i(x_i^0)}{w_i}.$$

At the same time the condition should be satisfied:

$$\sum_{i=1}^{N} v_i(x_i^*)=\sum_{i=1}^{N} w_i=1.$$

Obtained evaluations of values' differences are sufficient to support conclusions about the preferences of the decision maker, taking into account:

1. Ordinal ranking.

We assume that the decision maker prefers x_i^j as compared to x_i^k. From this it follows that:

$v_i(x_i^j)-v_i(x_i^k)>0$.

That is, the ranking gives rise to a number of linear restrictions in relation to single evaluation functions of attributives.

2. Determination of ratios of differences of values (numerical ranking).

Let L and U be respectively lower and upper limits of the ratio of the differences of values:

$$L\le\frac{v(x_j)-v(x_k)}{v(x_l)-v(x_m)}\le U.$$

From this it follows that:

$$\begin{cases} -v(x_j)\,v(x_k)+L(v(x_l)-v(x_m))\le 0 \\ v(x_j)-v(x_k)-U(v(x_l)-v(x_m))\le 0 \end{cases}$$

3. Direct comparison of alternatives in relation to objectives (holistic comparisons).

In comparisons of this type techniques of ordinal and numerical ranking are applied to the evaluation function of the objectives. For example, if DM considering a purpose o_i, prefers the value x^1 as compared to x^2, it indicates that:

$v_{oi}(x_{oi}^1)-v_{oi}(x_{oi}^2)>0$,

where v_{oi} is a function of an overall evaluation as to the purpose o_i, and x_{ai}^i – the value of the alternative $i\in\{1,2\}$ in relation to the purpose o_i.

Ranking of alternatives

To adjust the evaluation function the results of a direct comparison can also be used. For example, by correlating $v_i(x_i^j)$ with the best and the worst values x_i^* and x_i^0:

$$L\le\frac{v_i(x_i^j)-v_i(x_i^0)}{v_i(x_i^*)-v_i(x_i^0)}\le U.$$

Attribute weights are traditionally determined using SWING method. The algorithm consists of two phases:

1. One of the attributes with the highest level of importance gets its evaluation as 100 points.

2. The remaining attributes in turn are compared with the most important one. According to the results for each of them a range of values of importance is assigned [L, U].

Received suggestions of experts on the ranges of values of importance generate inequations:

$$\frac{L}{100}\le\frac{w_i}{w_{ref}}=\le\frac{U}{100}\Leftrightarrow\frac{L}{100}\le\frac{v_i(x_i^*)-v_i(x_i^0)}{v_{ref}(x_i^*)-v_{ref}(x_{ref}^0)}\le\frac{U}{100}.$$

At the last stage of the analysis by PRIME method synthesis of priorities of alternatives is carried out. By solving the linear programming tasks from inequations generated by experts we receive:

1. Interval evaluations of alternatives.

$$V(\mathbf{x})\in\left[\min\sum_{i=1}^{N} v_i(x_i),\max\sum_{i=1}^{N} v_i(x_i)\right].$$

2. Intervals of attributes weights.

$$w_i\in\left[\min\left\{v_i(x_i^*)-v_i(x_i^0)\right\},\max\left\{v_i(x_i^*)-v_i(x_i^0)\right\}\right].$$

3. Structures of preferences.

Absolute and paired dominations are distinguished. The alternative x^j is more preferable than the alternative x^k in the sense of absolute domination, if the intervals of their values do not overlap. That is the smallest value x^j exceeds the maximum value of the alternative x^k:

$$\min\sum_{i=1}^{N} v_i(x_i^j)>\max\sum_{i=1}^{N} v_i(x_i^k).$$

The alternative x^j is more preferable than the alternative x^k in the sense of paired domination if:

$$\max\left(V(\mathbf{x}^k)-V(\mathbf{x}^j)\right)<0\Leftrightarrow$$

$$\max\left(\sum_{i=1}^{N} v_i(\mathbf{x}^k)-\sum_{i=1}^{N} v_i(\mathbf{x}^j)\right)=\max\left(\sum_{i=1}^{N} w_i\left(v_i^N(\mathbf{x}^k)-v_i^N(\mathbf{x}^j)\right)\right)<0.$$

In other words, for any fixed set of weights w_i normalized (weighted) minimum value of the alternative x^k is higher than the maximum normalized (weighted) value x^j. It should be noted that the paired domination is less stringent than the absolute. In addition, the paired one for x^k and x^j are worth checking only if $\max(V(x^j)) > \max(V(x^k)) \geq \min(V(x^j)) > \min(V(x^k))$.

If the first inequation is not satisfied, then regardless of further adjustments to the model of preferences, evaluation of the alternative x^j cannot exceed the value of x^k. When the second inequation is not satisfied, then x^j dominates x^k absolutely. Finally, if the last inequation is not satisfied, then there are such values of weights w_i i=1..., N, at which the value of x^k is higher than the value of x^j. Consequently, the situation of domination may occur or be excluded completely, depending on the interval of estimates when the condition is not satisfied.

4. The results of the application of logical rules.

Rule maximax reveals an alternative with the maximum possible value, maximin – with the maximum lower bound of the evaluation. Rule minimax regret finds an alternative for which the maximum possible value of importance loss (and hence the error of its selection as dominant) is minimal:

$$\max_{j, j\neq k}\left[\max\left(\sum_{i=1}^{N} v_i(x_i^j) - \sum_{i=1}^{N} v_i(x_i^k)\right)\right].$$

Rule of central values reveals an alternative with the maximum average value of the estimation interval.

Thus, PRIME method has a strong mathematical foundation. Simulation or statistical tools are not used. Conclusion on the basis of logical rules allows determining the non-dominated alternatives, even in situations where other methods based on preference relations, are powerless.

Methods of ELECTRE family

This family focuses on solving problems of multicriteria choice with a given set of alternatives. These methods are based on relative determining of the quality level of alternatives on criteria, i. e. quality of alternatives on many criteria is represented not in the form of a generalized quantitative evaluation, but on the basis of detection of conditions of superiority of one alternative over another.

The traditional formulation of the problem of decision-making is as follows. There are n criteria, measuring scales for alternatives quality on these criteria (usually quantitative), criteria weights (usually integers), a finite set of alternatives and their evaluation according to the criteria.

We introduce the following notations: $A = \{A_1, A_n\}$ – a set of alternatives; $I = \{K_1,..., K_n\}$ – set of criteria, according to which each alternative $A_i \in A$ can be evaluated. A set I can be divided into three subsets (classes):

$I^+(A_i, A_j)$ – a subset of criteria according to which A_i is more preferable than A_j;

$I^=(A_i, A_j)$ – a subset of criteria according to which A_i is equivalent with A_j;

$I^-(A_i, A_j)$ – a subset of criteria according to which A_j is more preferable than A_i.

Supposing that it is possible to determine the relative importance of each of these subsets, which is characterized by three numbers: $P^+(A_i, A_j)$, $P^=(A_i, A_j)$, $P^-(A_i, A_j)$.

We introduce a threshold c and we assume that A_i is superior to A_j, if the condition is satisfied

$c\,[P^+(A_i, A_j), P^=(A_i, A_j), P^-(A_i, A_j)] \leq c.$ (1)

The left side of this inequation is called the index of consent, the right – the threshold of dissent.

In ELECTRE-I method the index of consent is defined as the sum of

$P^+(A_i, A_j) + P^=(A_i, A_j)$ or in the form

$(P^+(A_i, A_j) + P^=(A_i, A_j)) / (P^+(A_i, A_j) + P^=(A_i, A_j) + P^-(A_i, A_j)) \geq c.$ (2)

To avoid the situation, when A_iRA_j and A_jRA_i (where R is a binary relation of superiority (preferences) defined on the set of alternatives A) are satisfied simulteneously, instead of (2) the following condition can be used

$P^+(A_i, A_j) / P^-(A_i, A_j) \geq c.$ (3)

Thus, condition (2) is recommended when the number of the matching evaluations in different embodiments is relatively small as compared to n, otherwise the condition (3) is advisable.

In ELECTRE-II method the described approach and the condition (3) are used. For practical calculations by the ELECTRE-I and ELECTRE-II methods we can take the expression:

$$P^*(A_i, A_j) = \sum_{i \in I^*(A_i, A_j)} p_i\,, \qquad (4)$$

*where * is any symbol from the set {+, =, –}; p_i – weight, representing the importance of i-th criterion from the set I.*

The condition (1) is necessary but insufficient to establish a relation of superiority in the pair (A_i, A_j). Therefore the index of dissent is applied:

$d(A_i, A_j) \leq d,$

where d is a threshold of the index. Indexed condition takes into account the values of the differences between the estimates of the quality of alternatives according to certain criterion. And the index is calculated by the formula:

$$d(A_i, A_j) = \max_{k \in I^-(A_i, A_j)} \frac{I^k_{A_j} - I^k_{A_i}}{L_k}\,, \qquad (5)$$

where $I^k_{A_i}$, $I^k_{A_j}$ are evaluations of alternatives A_i, and A_j to the criterion k; L_k – the value of the maximum gradation of the scale (its length), used to measure the criterion.

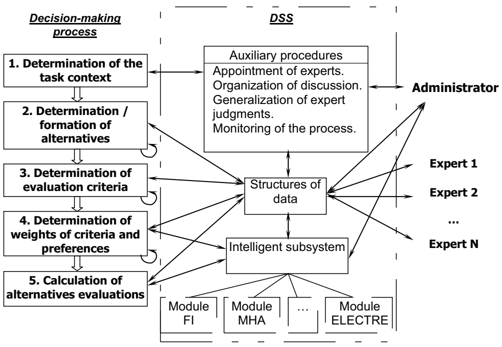
Hence, the ratio of preference for alternatives A_i and A_j is defined as follows: A_iRA_j, if $c\,[P^+(A_i, A_j), P^=(A_i, A_j), P^-(A_i, A_j)] \geq c$ and $d(A_i, A_j) \leq d$.

Methods of the group ELECTRE imply formation of the core on the set of initial options (alternatives) A, all elements of which are incomparable (i. e., form a set of Pareto), and any option, not included in the core is dominated by at least one of its elements. Narrowing of the core can be achieved by increasing the threshold value of the index of consent of the index c and decreasing the threshold of the index of dissent d. It should be noted that in the presence of Pareto-optimal alternative (which by all criteria is not worse than other alternatives and is better on at least one criterion) a core is formed containing a single element, as this alternative dominates all the others.

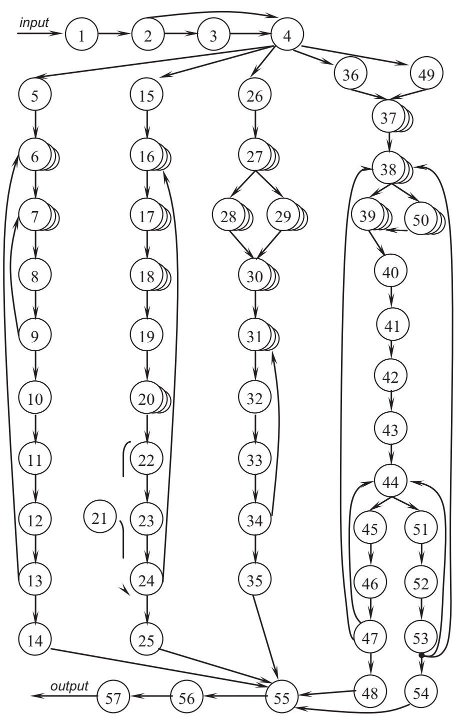
Software implementation of DSS

The structure of DSS is shown in Pic. 1. Database (DB) of the system contains a general description of the problem, hierarchical and network structures of criteria, results of a survey of experts and their correspondence, values of alternatives attributes (derived from the enterprise information system or entered directly by the administrator), and other information. Knowledge base (KB) includes practical problems, solved by various methods.

Management subsystem of DB and KB base mainly allows the administrator to organize and



Pic. 2. Scheme of a process of multi-criteria decision-making with the help of DSS.



Pic. 3. Generalized functional model of DSS based on multi-criteria methods of decision-making under uncertainty.

coordinate the preparation of solutions. The access of experts in DSS is also performed through it. The use of passwords and assignment of access privileges ensure information security.

KB function is also implementation using inferences of the choice of the most optimal decision-making method for a particular situation. In accordance with this type of the problem, structure and nature of the problem data, the number of criteria, alternatives etc. are analyzed. At the request of the user evaluation can be conducted by several available methods. In this case, the final choice (the use of particular options) remains for a man.

Intelligent subsystem takes the original information from the database, generalized by the administrator, and adds formalized expert knowledge stored in KB. User interaction with DSS occurs through interface modules.

Data from the loops of the enterprise information system come automatically or on request from the administrator. They include accounting, finance, and management information of the current or past periods. Pic. 2 shows a scheme of decision-making process in the automated decision support system. At the first stage, the administrator receives a request from a user, defines a group of experts working on the problem. For them, access privileges, passwords and polling sequence (if required) are assigned.

At the second stage a list of alternatives is determined and specified. This procedure, as well as the following two steps, is performed iteratively until an administrator records the achievement of consensus or the required number of votes.

For aggregation of collective assessments different principles of compromise are used: egalitarianism, utilitarianism, a fair compromise, etc. It takes less effort and time from participants of the process, than by consensus. However, it may not remove the conflict of goals or interests. The administrator eliminates data redundancy, for example, when it encounters exactly the same voting options.

Determination of the list of goals and criteria (third step) is usually faster. The proposed criteria represent views of different actors (individuals, influencing the decision-making process). Therefore, the inclusion of the maximum number of options for providing ensures a more comprehensive coverage of the problem. Discussions may arise with regard to the redundancy of attributes or their weak representativeness. At this stage the profile of the problem is finally formed, and an intelligent subsystem selects the optimal method of assessment. Then at the fourth stage standard questionnaires and forms are sent to the experts for entering the required information: final configuration of the model, criteria weights, degrees of alternatives preferences, etc.

Iterative implementation of the fourth stage becomes mandatory at the poor consistency or heterogeneity of judgments. If professionalism of experts varies widely, their opinions may be adjusted by weighting the ratings.

At the fifth stage, when all information is entered into databases and knowledge bases, estimates of alternatives is calculated by selected methods. User interfaces of DSS have to support a conclusion of the results in a convenient format for the decision maker: text or graphics.

Generalized functional model of DSS

In Pic. 3 it is represented as a directed graph. Each node corresponds to a logically complete procedure, implemented in the form of independent subprogram. Oriented edges of the graph indicate the direction of information transmission and the transition from one procedure to another. Situations of choice (when the user invokes a method of solving the problem) or branching of the processes are possible which are associated with test of logical conditions.

Operation of the system begins with the activation of user interface modules and calling of lists of earlier introduced alternatives, objectives and methods. Output is possible at the logical conclusion of any of the stages. Support for asynchronous communication of participants of decision-making process enables to continue working on the task at any time, if its limit set by the administrator is not exceeded. At the same time an order for the basic procedures for each of the used methods is provided. Place of the procedure in the graph is *determined by its serial number and generally is reduced to a few positions:*

1. Input / editing descriptions of alternatives.

2. Input / editing goals and criteria of the task.

3. Automatic selection of solution methods by intellectual subsystem.

4. Selection of data from the enterprise information system.

The final stage of the work with the program is followed by:

1. Visualization of the results of evaluation by various methods.

2. Printing of reports.

3. Storage of the task environment in DB and KB, and the output from the system.

In Pic. 3 the nodes of the graph of the form mean information input procedures that may be performed repeatedly, depending on the number of voters. In the nodes (6, 16, 27, 37) experts complement the general structures of method models in accordance with their competencies (e. g., by functional area). Collaborative work together with the same area of the problem is possible. When creating hierarchies, trees purposes etc. using the database interface data on alternatives previously entered are used.

Reverse transitions from the latter to the initial procedures are performed, if it is necessary to specify the model. In the methods of MNA and MHA matrices of pairwise comparisons are adjusted again, if the calculation of the index of consent has given an unsatisfactory result. Transition (9–7) is activated when, after comparing the elements it is necessary to compare their clusters with each other. Algorithm procedure (7) is versatile, and a particular case is determined by transmission of relevant parameters.

In PRIME method branching (27–28,29) is the user's choice of one or another way to specify criteria weights. Return to specify judgments (34–31) takes place not by the beginning of the chain, but by the step of quantitative preferences evaluation. Output of the cycle occurs when the degree of possible loss of significance becomes acceptable.

ELECTRE methods generally use single procedure. Last stages (45–47 and 51–53) are different. In ELECTRE profiles of categories (50) are described additionally. After this, assignment of preferences parameters (39) is carried out in the cycle according to the number of profiles. Return in case of model calibration may occur to the step of determining weights of criteria or determining the cutting off level λ (in a procedure to eliminate uncertainty of preference relation – 44).

In case of fuzzy inference logging of judgment (21) is parallel to the procedures of fuzzification, actually output and defuzzification (22–24).

Conclusions. *As the analysis of the functional model has shown, a clear distinction between modes of acquiring knowledge and consultations is obtained only for the class of ELECTRE and fuzzy inference methods. In the methods of PRIME, MNA and MHA introduction of new alternatives is associated with their additional comparing in relation to criteria of the next level. Even if the number is not large, this procedure refers to a mode of acquiring knowledge and should be performed by experts.*

Elimination of the mentioned problem is admissible in two ways. Firstly, experts can assess the maximum number of alternatives in advance. But such an approach is unacceptable in monitoring of business processes, as the number of potential states of the system is indefinite. Secondly, in MNA and MHA it is possible to apply the method of standards, which reveals quality levels on set criteria (standards) typical for the majority of alternatives. Obtained priorities of standards are associated with the proposed alternatives. Then the synthesis of quality values of the latter is perf ormed without additional analysis. This decision seems to be the most promising.

Ensuring support for consultations mode by PRIME method is only possible when using the utility function. Then this algorithm determines the upper and lower boundaries of preferences automatically without user intervention. Obviously, this approach is acceptable for attributes of quantitative nature. Comparison of qualitative characteristics is the prerogative of experts.

In conclusion it should be noted that these restrictions are relevant only for unskilled users. Application of DSS by experts does not exclude any methods and in any case greatly simplifies the decision-making process due to total or partial automation of its stages.

Keywords: *intelligent system, decision-making, transport infrastructure, forecasting, planning, group methods.*

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