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KDECISION-MAKING IN FRAGMENTARY - DISTRIBUTED SYSTEMS

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ABSTRACT

Problems of application in semistructurized and heavily formalized tasks of management are considered. The method of decision-making is offered on the basis of fuzzy relational model of knowledge representation at a horizontal and vertical fragmentation of knowledge base in view of hierarchical structurization of inequivalent criteria.

I. INTRODUCTION

The computer facilities finds more and more wide application in the matters of management. The majority of the commercial, public and state organizations do not accept serious decisions without the use of elements of the computer analysis by now. However, the application of computer facilities for the solution of administrative problems, introduction of decision-making support systems are usually accompanied by the serious difficulties interfering the use of all opportunities that computer technologies may present for generation and choice of variants of administrative decisions. Difficulty of these systems usage is connected by that the person at decisions working-out very much frequently bases not only (and in many cases at all so much) on methods of the formal analysis of situations and mathematical methods of the best result detection, but also on the experience and intuition.

To overcome these difficulties significant efforts were undertaken as in the field of development of the methods, allowing to use computing systems for the solution of management tasks, as in creation of necessary hardware and software realizing these methods.

Problems of decision-making stand especially sharply at a level of systems where the management tasks are semistructurized and heavily formalized. Such systems are characterized by the following features [1]:

1. Functioning in conditions of ambiguity, discrepancy and incompleteness of the data and knowledge of object and, thereof, absence of the optimum purpose of functioning.

2. Presence of unacceptable complex formalized description of object as the significant part of the information necessary for the mathematical description of object exists in the form of subjective knowledge of experts and has mainly qualitative character.

3. Heterogeneity of the information on object (expert estimations, indications of devices, functional dependences between parameters, etc.).

4. Dispersion of object both territorially, and functionally and, accordingly, the necessity of registration of the distributed knowledge of the object.

5. A plenty of the factors describing object, and the limited amount of possible decisions at management of object.

Automation of decision-making process in management of the systems which are difficultly giving in to formalization is carried out by creation and conducting the distributed bases of knowledge and the development of special methods of acceptance on their decisions basis, allowing to take into account a various sort of functionally and geographically distributed knowledge of a subject domain, and also the requirement of collective decision-making by geographically separated people accepting the decision [2].

II. GENERAL DESCRIPTION OF DECISION-MAKING IN THE DISTRIBUTED ENVIRONMENT

Search of necessary knowledge and acceptance of decisions on their basis in the distributed environment in many respects depends on type of knowledge distribution, i.e. on the way of the knowledge base (KB) organization.

Fragmentary - distributed KB assumes the presence several equally organized knowledge sub-bases on the various network units, the totality of which defines the whole KB.

Fragmentary - distributed KB will consist of the local subsystems located in units connected among themselves of the computer network, each of which can independently solve the particular tasks, but none of them possess the sufficient knowledge, the information and resources for solution of general problem.

Decision-making process on a basis of fragmentary distributed KB is of large-scale character. Therefore at realization of decision-making the process also is broken into stages or parts. One of the basic criteria of splitting of decision-making process is its representation as separate decisions by fragments (local KB). Thus the resulting decision is accepted in the upshot of the particular decisions analysis. In some cases for resulting decision-making it is possible to prove validity of superposition principle that can be formulated as follows: if decision-making process is broken into set of sub-processes by fragments, the availability of the best decision in the set of the best sub-processes decisions chosen under fragments is possible.

However, this statement is fair not for all ways of KB fragmentation.

Let's consider methods of decision-making at horizontal and vertical KB fragmentation taking into account inequivalents and a hierarchical estimation of criteria with use of fuzzy logic device. For knowledge representation there is used fuzzy relational model of knowledge representation [3], on the basis of which decision-making process is reduced to a problem of the best alternative choice among possible ones that allows to carry out ranging of alternatives by the generalized criterion.

According to this model, if $X = \{x_1, x_2, \ldots, x_n\} = \{x_i, i = \overline{1,n}\}$ is a set of allowable alternatives among which it is necessary to choose the best, and

$K = \{k_1, k_2, ..., k_m\} = \{k_j, j = \overline{1,m}\}$ - is a set of criteria, parameters and the properties inherent in alternatives the set of allowable alternatives is represented by a two-dimensional relational matrix in which the degree of satisfaction of alternative x_i to criterion kj is defined by the membership function $\varphi_{k_j}(x_i): X \times K \rightarrow [0,1]$.

III. DECISION-MAKING AT HORIZONTAL DISTRIBUTION OF KB

Horizontal – distributed KB satisfies to the following conditions: $X = \bigvee_{i=1}^{N} X_i$, where X *is a* set of alternatives. X_1 is a subset of alternative set in i-subsystem, $X_i \cap X_j = \varnothing$ *for* $\forall\ i \neq j$ *and* $K_i \cap K_j = K_i = K_j = K$ for $\forall\ i, j$, where K *is a* set of criteria (tab. 1). In other words, in each subsystem various alternatives should satisfy to the same criteria. Criteria are hierarchically structured, i.e. $K = \{K_1, K_2, ..., K_M\} = \{K_m, m = \overline{1,M}\}$,

$K_m = \{\kappa_{m1}, \kappa_{m2}, ..., \kappa_{mT}\} = \{\kappa_t, t = \overline{1,T}\}$, and inequivalent.

Decision-making process at horizontal fragmentation KB is reduced to performance of the following steps.

1. By means of criteria aggregation at the bottom level particular criteria of the top level are estimated, i.e. if $\{\varphi_{k_{m1}}(x_{ig}), \varphi_{k_{m2}}(x_{ig}), ..., \varphi_{k_{mT}}(x_{ig})\} = \{\varphi_{k_{mt}}(x_{ig}), t = \overline{1,T}\}$ are functions of membership x_{ig} alternative to particular criteria $k_{m1}, k_{m2}, ..., k_{mT}$ и $w_{m1}, w_{m2}, ..., w_{m}$– are factors of relative importance of these partial criteria in i-subsystem, the construction of convolution of these inequivalent particular criteria defines the membership function of x_{ig} alternative to K_m generalized criterion

$$\varphi_{K_m}(x_{ig}) = \sum_{t=1}^{T} w_{mt}\ \varphi_{mt}(x_{ig})$$

are estimated:

Table 1. KB Structure at a horizontal fragmentation.

Fragment	Alternatives by fragments	K							
		K_1				K_M			
		κ_{11}	...	κ_{1T}		κ_{M1}	...	κ_{Mm}	
X_1	x_{11}	$\varphi_{k_{11}}(x_{11})$		$\varphi_{k_{1T}}(x_{11})$		$\varphi_{k_{M1}}(x_{11})$		$\varphi_{k_{Mm}}(x_{11})$	
	.....	.....		.....		.....		.....	
	x_{1E}	$\varphi_{k_{11}}(x_{1E})$		$\varphi_{k_{1T}}(x_{1E})$		$\varphi_{k_{M1}}(x_{1E})$		$\varphi_{k_{Mm}}(x_{1E})$	
...	...	...		...		...		...	
X_N	x_{N1}	$\varphi_{k_{11}}(x_{N1})$		$\varphi_{k_{1T}}(x_{N1})$		$\varphi_{k_{M1}}(x_{N1})$		$\varphi_{k_{Mm}}(x_{N1})$	
	.....	.....		.....		.....		.....	
	x_{Nn}	$\varphi_{k_{11}}(x_{Nn})$		$\varphi_{k_{1T}}(x_{Nn})$		$\varphi_{k_{M1}}(x_{Nn})$		$\varphi_{k_{Mm}}(x_{Nn})$	

2. In each horizontally-distributed subsystem the grade of membership of x000 alternative to the generalized criterion K: $\varphi_K(x_{ig}) = \sum_{m=1}^{M} w_m \varphi_{Km}(x_{ig})$.

3. In each horizontally-distributed subsystem the alternative that possesses maximum grade of membership to generalized criterion K $\varphi_K(x_t^*) = \max\left[\varphi_K(x_{ig}), g = \overline{1,G}\right]$ is being selected. G - is a number of alternatives in horizontally-distributed i-subsystem. Chosen alternative is the best alternative in i-subsystem.

4. Maximal $\{\varphi_K(x_i), i = \overline{1,N}\}$ is being selected among set of membership function values in N-horizontally distributed subsystems $\varphi(x^*) = \max\{\varphi_K(x_i), i = \overline{1,N}\}$. The alternative, corresponding to maximal value is the resulting decision in horizontally-distributed KB and it is located in the set of best alternatives by fragments, i.e - $x^* \in \{x_i^*, i = \overline{1,N}\}$.

As follows from above-stated, at horizontal fragmentations of KB the principle of superposition of decision-making process is fair, i.e. the best decision is in set of the best decisions of the subprocesses chosen by fragments.

IV.DECISION-MAKING AT VERTICAL DISTRIBUTION OF KB

Vertically - distributed KB satisfies to the following conditions: $K = \bigvee_{m=1}^{M} K_m$, where K set of not equivalent criteria K_m, $m = \overline{1,M}$ and K_m - is a subset set of criteria in m-subsystem, $K_j = \varnothing$ *for* $\forall\ m \neq j$ and $X_m \cap X_j = X_m = X_j = X$ for $\forall\ m, j$, where X- is *a* set of alternatives and $X = \{x_1, x_2, ..., x_N\} = \{x_i, i = \overline{1,N}\}$ (tab.2). In other words, at KB vertical distribution in each subsystem identical alternatives are characterized by different inequivalent criteria.

Table 2. KB structure at a vertical fragmentation.

Alternatives	K						
	K_1			...	K_M		
	κ_{11}	...	κ_{1T}		κ_{M1}	...	κ_{Mm}
x_1	$\varphi_{k_{11}}(x_1)$	...	$\varphi_{k_{1T}}(x_1)$	...	$\varphi_{k_{M1}}(x_1)$	...	$\varphi_{k_{Mm}}(x_1)$
x_2	$\varphi_{k_{11}}(x_2)$	...	$\varphi_{k_{1T}}(x_2)$	...	$\varphi_{k_{M1}}(x_2)$	...	$\varphi_{k_{Mm}}(x_2)$
...	...	...	...	...	...	...	...
x_N	$\varphi_{k_{11}}(x_N)$	...	$\varphi_{k_{1T}}(x_N)$	...	$\varphi_{k_{M1}}(x_N)$	...	$\varphi_{k_{Mm}}(x_N)$

Decision-making process at KB vertical fragmentation can be reduced to performance of the following steps.

1.If $\{\varphi_{k_{m1}}(x_i), \varphi_{k_{m2}}(x_i), ..., \varphi_{k_{mT}}(x_i)\} = \{\varphi_{k_{mt}}(x_i), t = \overline{1,T}\}$ are the functions of membership of x_i alternative to particular criteria $k_{m1}, k_{m2}, ..., k_{mT}$ и $w_{m1}, w_{m2}, ..., w_{mT}$ –are factors of relative importance of these particular criteria in m-subsystem, construction of convolution of these inequivalent particular criteria determines the function of membership of x_i alternative to generalized criterion $_m$:

$$\varphi_{K_m}(x_i) = \sum_{t=1}^{T} w_{mt}\ \varphi_{mt}(x_i)$$

2. In each vertically - distributed to a subsystem the alternative possessing the maximal grade of membership to generalized criterion K_m is being selected: $\varphi_{Km}(x) = \max\left[\varphi_{Km}(x_i), i = \overline{1, N}\right]$, where N *is a number* of alternatives. The chosen alternative is the best alternative in m-subsystem or on generalized parameter K_m.

3. The grade of membership of x_i alternative to the generalized criterion K is being defined: $\varphi_K(x_i) = \sum_{m=1}^{M} w_m \varphi_{Km}(x_i)$. Here w_m *is a factor* of relative importance of K_m criterion.

4. The alternative possessing the maximal grade of membership to generalized criterion K is being chosen: $\varphi_K(x^*) = \max\left[\varphi_K(x_i), i = \overline{1, N}\right]$. The alternative corresponding to the maximal value is the resulting decision in vertically - distributed KB.

At KB vertical fragmentation the principle of superposition of decision-making process is unfair, i.e. solution of the best decision in set of the best decisions of the subprocesses chosen by fragments, not always is satisfied.

V. THE CONCLUSION. In Institute of Information Technology of the National Academy of sciences of Azerbaijan the decision-making support system is realized for an estimation of personnel activity, basing on the suggested methods [4].

References:

1. A.M.Abbasov, M.H.Mamedova. Methods of the organization of bases of knowledge with fuzzy relational structure. Baku, Элм, 1997.-256 with.

2. Abbasov A.M., Aliev E.R., Mamedova M.H., Dzhabrailov Z.G. Architecture and principles of realization of the distributed systems of decision-making. Managing systems and machines, №5, 1993, with 71-79.

3. M.H.Mamedova. Decision-making on the basis of knowledge bases with fuzzy relational structure. Baku. Элм, 1997.-296 with.

4. Mamedova M.G., Dzhabrailova Z.G., Aliev G.B. Fuzzy logic in system of personnel cadre monitoring. In resource.: Modern problems of social and economic development and information technologies. The collection of works. Baku - 2004.стр.105-112.