A SYSTEM APPROACH TO SOLVING FORESIGHT PROBLEMS ON THE BASIS OF DELPHI METHOD

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Abstract: Based on the experience of solving problems of foresight, it should be noted that the multi-factor, multi-parameter, heterogeneous and weakly structured information of the researched subject areas used at different stages of the process of foresight, leads to difficulties related to the presentation of knowledge, the construction of the survey forms, results processing and coordinated control foresight process as a whole. In order to effectively implement the process of scenario analysis it is expedient in on-line mode to develop automated tools for knowledge extraction, coordinated distribution of data flow of its processing, means in-depth analysis of the studied subject areas, taking into account all the necessary factors for the studied problem. In this article, with that said, the technique of building the information model of knowledge within a single system approach

Keywords: Delphi method, knowledge base, information model of knowledge, questionnaires, expert evaluation, the agreed expert opinion

ACM Classification Keywords: H.4.2. INFORMATION SYSTEM APPLICATION: type of system strategy
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Introduction

Using the foresight methodology is based on the identification of key technologies (critical technologies) and the construction of object future scenarios, to support decision-making at the levels of government, industry or individual institutions and companies in the formation of the most effective science and technology policy and planning for its development [1]. Application of the scenario analysis to solve practical foresight problems is carried out, first of all, by bringing the methods of qualitative analysis, requiring intuition, experience and knowledge of experts in the peer evaluation in various subject areas for the solution of problems of strategic planning and decision-making.

In solving problems of foresight it is necessary to consider the details and specifics related to the necessity of obtaining and processing large volumes of diverse heterogeneous information for further analysis and decision-making at every stage of foresight. For a wide range of problems not formalized in the political, economic, social and other fields and areas of human activity expert estimation methods are the main and most acceptable way to solve them. One of the most used methods of this group is the Delphi method.

However, the complexity, lack of completeness and accuracy of the information distributed management of data flows require new tools and approaches to obtain information from the experts needed for the formation of alternative scenarios [2]. From the specified should be the need to develop automated tools and a common system approach to solving problems of foresight based on the Delphi method.

1. A system approach to solving problems of foresight based on the Delphi method

A system approach to solving problems of foresight, based on the formation of a structured knowledge base as an information platform core scenario analysis, and generation of the survey forms, formalized procedures of expert estimation based on the Delphi method and its application in the mode of on-line, is proposed (Fig. 1).

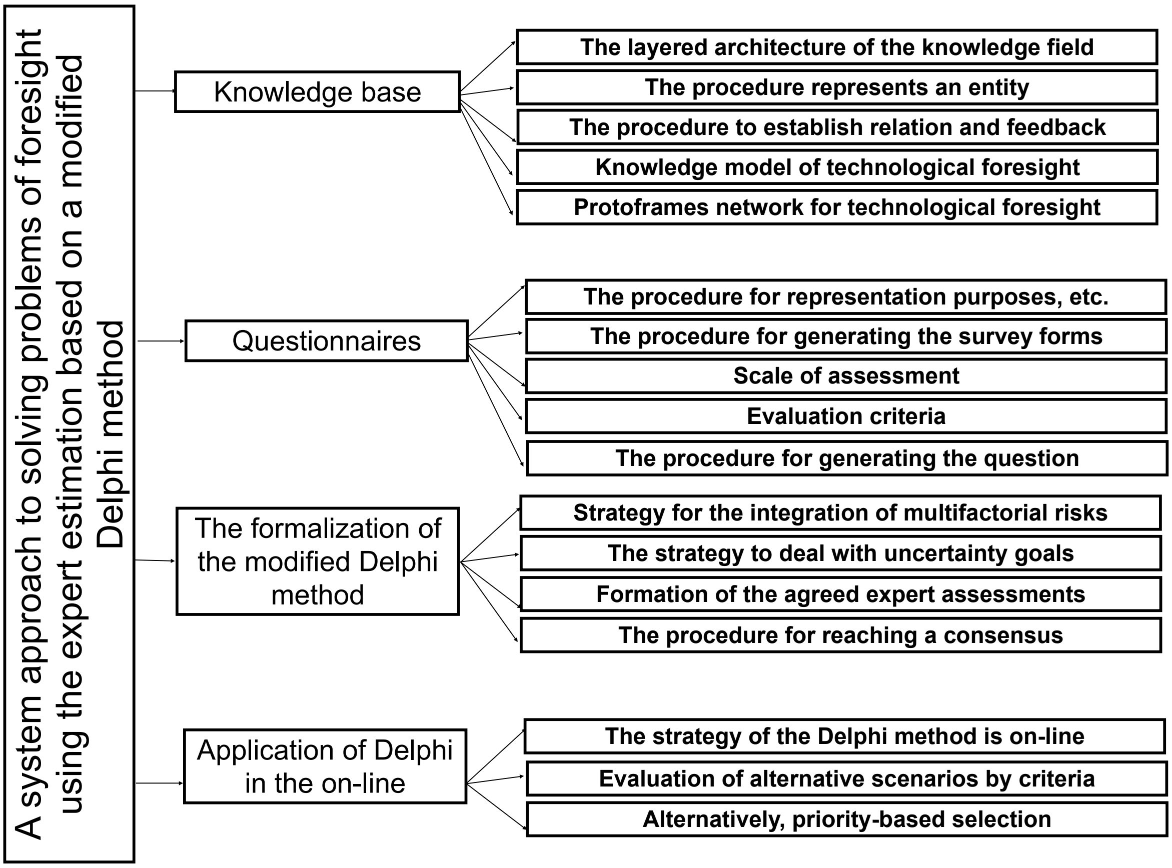

Figure 1. Block diagram of a system approach to solving foresight problems on the basis of Delphi method

Let consider the stages of strategy system approach to solving foresight problems, involving expert evaluation procedure based on the Delphi method and the creation of automated tools.

1.1. Knowledge base

In the construction of an automated tool for solving problems of foresight it is necessary to form a single information space containing homogeneous related structured data obtained from different sources: electronic documents, spreadsheets, semantic fragments extracted from text documents, etc. The proposed software of the data selection from the documents forms the basis of the data on the domain knowledge of the object. The main stages of building the knowledge base are described in [3].

In the process of building a goals tree $G = \{g_i \mid i = \overrightarrow{1, N_G}\}$ of study object O_G is seen in the complex of interrelated and interdependent problems. The procedure of describing the variants of measures sequence to achieve the objectives g_i is reduced to the procedure of describing the current context of the situation $C(T_0, S_0)$, in which there is a considered object at the current time T_0 in the current space S_0, the desired context of the situation $C(T_G, S_G)$ of the ultimate goal of the study, as well as a set of successive versions of the transitions between them $C(T_j, S_j)$, which in turn form the alternative scenarios $Sc_k = \{C(T_j, S_j) \mid j = \overrightarrow{0, N_{Gk}}\}$.

The knowledge field discussed in the relevant sections $\Pr = \{\Pr_i \mid i = \overrightarrow{1, N_{\Pr}}\}$ and levels $\Pr_i = \{L_{ij} \mid j = \overrightarrow{1, N_{\Pr_i}}\}$, the number and structure of which is limited as the scale of the network formed by the framing. The proposed architecture scales the field of knowledge objects to the desired level composition and allowing them to correlate with each other to compare the most important sections, that enables to move from a linear representation of complex plane entity to a simple hierarchical structure forming ordered knowledge based foresight features of the process [3].

In the process of formation of fields frame structures F_i, the procedure represents an entity from a field of knowledge $F_i = C_i \bigcup_{i=1}^{N_{x_i}} X_{ij}$ with the establishment of appropriate backward and forward linkages $R_i = D_{i1} \bigcup S_i \bigcup D_{i2}$, which expands the range of unique titles to choose frames and reduces the risk of duplication in the knowledge base structuring information, making the procedure more acceptable to the analyst [4,5].

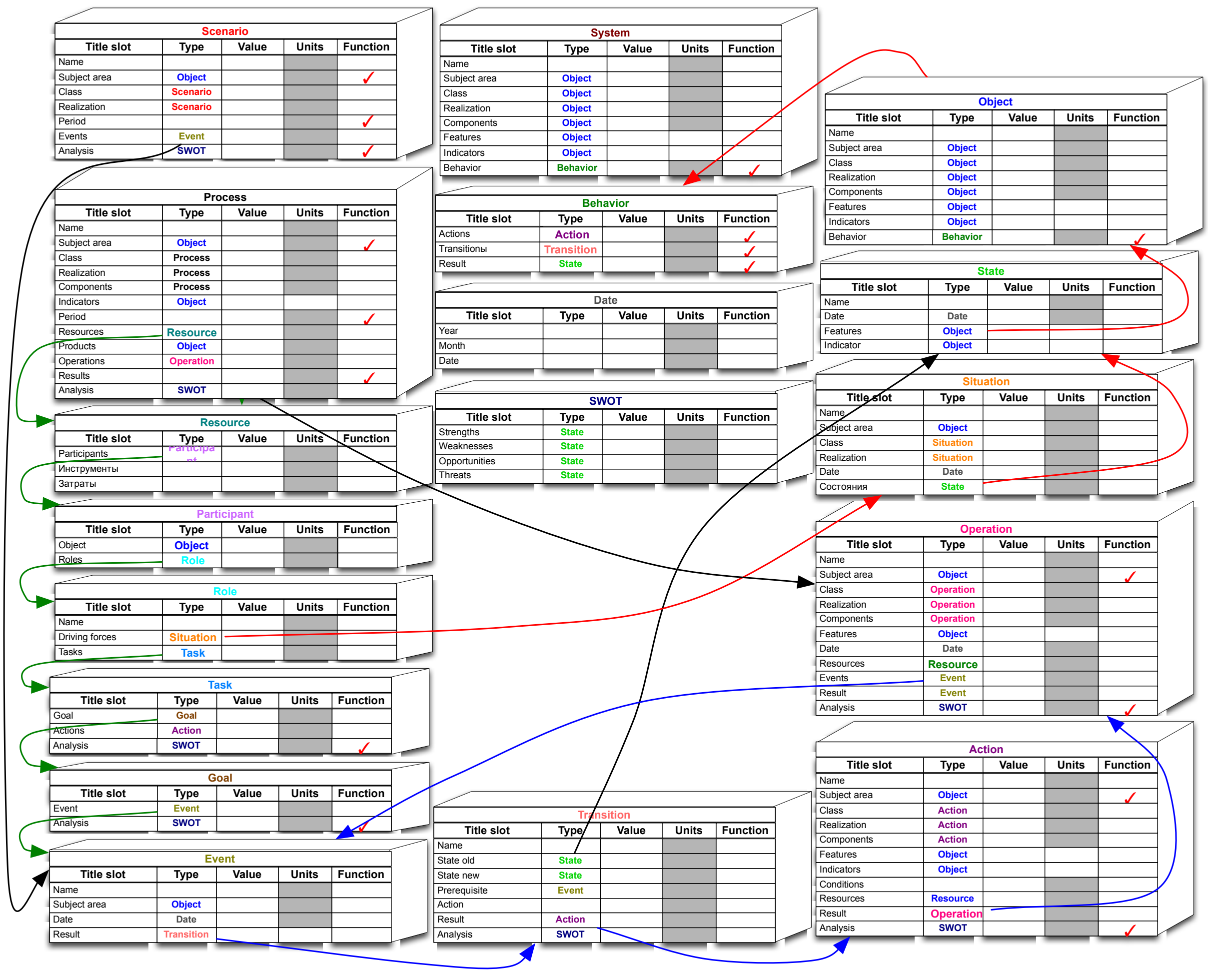

Figure 2. Frame-prototype network of technological foresight

Model of the knowledge field is defined as follows: $M =< F, R, P >$, where $F = \{F_i \mid i = \overrightarrow{1, N_F}\}$ - a lot of frames, $R = \{R_i \mid i = \overrightarrow{1, N_R}\}$ - a lot of semantic roles, $P = \{P_i \mid i = \overrightarrow{1, N_P}\}$ - finite set of relations between frames using the appropriate semantic roles where P_i is defined as: $P_i = \{F_i R_{ij} F_j \mid j = \overrightarrow{1, N_{P_i}}\}$, $\forall i = \overrightarrow{1, N_P}$.

Frame-prototype network of technological foresight, shown in Fig. 2, which is based on the information model of knowledge as a result of building the knowledge base, is represented in the form of cuts and layers containing interrelated and interdependent frames of problems, goals, situations, trends, scenarios, etc.

Frame-based approach to model building alternatives script generates quasi-dynamic knowledge control system that captures the values of a certain period of time, and allows you to build a network of transitions to create alternative scenarios for the future in accordance with the intended purpose of the study [6].

1.2. Questionnaires

In the process of solving the problems experts form possible events, conditions, solutions, evaluate the accuracy of the assumptions and hypotheses, the importance of the objectives on the basis of information given to them about the subject area, considered objects and relationships, characteristics, and performance [7]. The proposed method of construction of the survey forms for expert evaluation method based on the Delphi method helps to solve problems related to:

- Automatic generation of the survey forms the basis for research purposes;
- Correctness of the wording and presentation of the issue in order to avoid ambiguity interpretation of its meaning;
- Complete description of the context of the situation with its consequences, in which the question is asked, as well as the elimination of contextual redundancy;
- Ergonomic structure of the survey forms with a focus on the most important experts of key issues;
- Obtaining the results of the survey in the form of kid-machine interface and decision-makers;
- Inevitability of errors due to manual procedures for processing large amounts of information.

To achieve the objectives a formalization of stages of creating profiles was carried out and a module of automatic generation of the survey forms, which consists of an issue generation procedure and directly questionnaire form generation procedure was developed.

Each question in the survey form is generated from the context of the issue, the text in question and the scale of assessment:

The context of the question consists of:

1. Temporal boundaries;
2. Place;
3. Object;
4. Indicator;
5. Changes - changes from the present, affecting the rate of the object and reflect the picture in the specified time-frame and territories:
   - The name change;
   - Quality changes (degree);
   - The amount of change (scale).

Question:

Rate << Object >> << Indicator >> [and the degree of confidence in the response] for each level of << Scale >> evaluation within the context of the issue.

In order to improve the accuracy of the examination as a basis for estimating the scale 7-level scale of Miller was taken. The key indicators to determine the boundaries of the scale of estimation are:

- limiting interval $[V_{\inf};V_{\sup}]$ - the boundaries within which the indicator of an object is measured;
- General interval $[V_{\min};V_{\max}]$ - the boundaries within which the indicator of the object is under consideration.

For the evaluation of alternative scenarios of the main criteria in the construction of a 7-level scale of assessment have been taken:

- Efficiency;
- Feasibility;
- The degree of relation to the problem;
- Degree of confidence in the proposal.

Universal approach to the formation of the survey forms is to combine the different applications of the method of expert assessment based on the Delphi method in the analysis phase of the process of technological foresight that has been realized in a complex algorithmic procedures and the use of computer technology.

1.3. The formalization of the modified Delphi method

At present, in spite of the level of demand and the relevance of the Delphi method, virtually there are no mathematical formalization and the single system approach to creating coherent expert estimates.

In [8], a formalization of the process of harmonization of expert opinion in terms of fuzzy interval estimates $\overline{Q}_{np} = \{\overline{Q}_{npk} \mid k = \overrightarrow{1,K_{np}}\}$, $\overline{Q}_{npk} = \{[\overline{Q}_{npks};\overline{Q}_{npks}] \mid s = \overrightarrow{1,S}\}$ and interval metrics $\rho_{d_{npk_ik_js}} = \rho_{d_{npk_is},d_{npk_js}} = \max(|d^-_{npk_is} - d^-_{npk_js}|,|d^+_{npk_is} - d^+_{npk_js}|)$ in order to allow the interview on-line and building sound alternatives scenarios based on man-machine platform scenario analysis. The formalization of the modified Delphi method is carried out taking into account the k -expert competence χ_{npk} and confidence ν_{npks} a staged response for each s -level.

The main steps in the process of formation of the agreed expert assessments for p -th indicator n -th object on the set of interval estimates $\overline{Q}_{np}$ are [8]:

1. The calculation of the exponent of the importance $W_{np} = \{w_{npk} \mid w_{npk} = w_{np}(\overline{Q}_{npk})\}, \forall p = \overrightarrow{1,P_n}, \forall n = \overrightarrow{1,N}$:

$$w_{np}(\overline{Q}_{npk}) = (1 - \rho(\overline{Q}_{npk}, \hat{Q}))\chi_{npk} \tag{1}$$

for determination of which some steps should be carried out:

1.1. The calculation of the mathematical average $\overline{M}_{np} = \{[\overline{M}^-_{nps};\overline{M}^+_{nps}], s = \overrightarrow{1,S}\}$:

$$\overline{M}^-_{nps} = M\overline{Q}^-_{nps} = \frac{1}{K}\sum_{k=1}^{K_{np}}\overline{Q}^-_{npks} \tag{2}$$

1.2. The calculation of the integrated peer review $\overline{\overline{Q}}_{np} = \{[\overline{\overline{Q}}_{nps}^{-}; \overline{\overline{Q}}_{nps}^{+}], s = \overrightarrow{1,S}\}$:

$$\overline{\overline{Q}}_{nps}^{-} = \arg\min_{\overline{Q}_{npks}^{-}}(|\overline{Q}_{npks} - \overline{M}_{npks}^{-}|) \; ; \; \overline{\overline{Q}}_{nps}^{+} = \arg\min_{\overline{Q}_{npks}^{+}}(|\overline{Q}_{npks} - \overline{M}_{npks}^{+}|) \quad (3)$$

1.3. Computation of the valuation of the span $[0;1]$:

$$K_{np}^{-} = \frac{1}{S(\overline{\overline{Q}}_{np}^{-})} \; ; \; K_{np}^{+} = \frac{1}{S(\overline{\overline{Q}}_{np}^{+})} \quad (4)$$

1.4. The calculation of the Gaussian density $\widetilde{Q}_{np} = \{[\widetilde{Q}_{nps}^{-}; \widetilde{Q}_{nps}^{+}], s = \overrightarrow{1,S}\}$:

$$\widetilde{Q}_{nps}^{-} = \frac{1}{K_{np}^{-}\sqrt{2\pi\widetilde{D}^{-}}} e^{\frac{-(x_s - \overline{M}^{-})^2}{2\widetilde{D}^{-}}} \; ; \; \widetilde{Q}_{nps}^{+} = \frac{1}{K_{np}^{+}\sqrt{2\pi\widetilde{D}^{+}}} e^{\frac{-(x_s - \overline{M}^{+})^2}{2\widetilde{D}^{+}}} \quad (5)$$

1.5. The calculation of the cumulative peer review $\hat{Q}_{np} = \{[\hat{Q}_{nps}^{-}; \hat{Q}_{nps}^{+}], s = \overrightarrow{1,S}\}$:

$$\sum_{s=1}^{S} \rho(\widetilde{Q}_{nps}; \hat{Q}_{nps}) \to \min \quad \text{or} \quad \begin{cases} \sum_{s=1}^{S}\left(\left|\frac{1}{K_{np}^{-}\sqrt{2\pi\widetilde{D}^{-}}} e^{\frac{-(x_s - \overline{M}^{-})^2}{2\widetilde{D}^{-}}} - \hat{Q}_{nps}^{-}\right|\right) \to \min \\ \sum_{s=1}^{S}\left(\left|\frac{1}{K_{np}^{+}\sqrt{2\pi\widetilde{D}^{+}}} e^{\frac{-(x_s - \overline{M}^{+})^2}{2\widetilde{D}^{+}}} - \hat{Q}_{nps}^{+}\right|\right) \to \min \end{cases} \quad (6)$$

2. The calculation of the least remote peer review M_{np} , to determine the which one:

2.1. Build a matrix of distances between the estimates:

$$D_{np} = \{d_{npk_ik_j} \mid k_i, k_j \in \overrightarrow{1, K_{np}}\} \quad (7)$$

2.2. Calculate the vector sum for each row:

$$S_{np} = \{S_{npk} \mid S_{npk_i} = \sum_{k_j=1}^{K_{np}} d_{npk_ik_j}, k_i = \overrightarrow{1, K_{np}}\} \quad (8)$$

2.3. The minimum of the vector:

$$M_{np} = \arg\min_{k=\overrightarrow{1,K_{np}}}(S_{npk}) \quad (9)$$

3. The calculation of the confidence interval T_{np} :

$\overline{Q}_{npk} \in T_{np}$, if $\widetilde{\rho}_{npk} = \rho(M_{np}, \overline{Q}_{npk})(1 - w_{npk}) < R_1^{(T_{np})}$, where $R_1^{(T_{np})}$ - a priori specified radius. (10)

4. The calculation of the indicator consistency $S^{(T_{np})}$:

$$S^{(T_{np})} = \frac{Card(T_{np})}{Card(E_{np})} \tag{11}$$

The criterion for the end of the examination procedure may be, for example, the excess indicator $S^{(T_{np})}$ a priori specified level S^*.

The main advantages and features of the interactive dialogue of the formation of the agreed expert opinion in the implementation of the Delphi method are:

opportunity to incorporate new ideas of experts;

- Opportunity to incorporate new ideas of experts;
- The focus on the views of opposition;
- Ensure coherence of confrontations (formation of consensus, which is the best option, not a choice of one of the opposites);
- Providing an incentive for creativity.

This formalization involving techniques of artificial intelligence is the basis of the computational algorithm and automated toolkit providing the peer evaluation in the on-line as part of the Information Platform scenario analysis [2].

1.4. Application of Delphi in the on-line

The strategy of the system approach in the on-line as automated tools of support of the process of foresight is shown in Fig. 3.

The block diagram shown in Fig. 3 demonstrates all the steps of the above sections from the construction of the tree of goals and building a knowledge base to automatic generation of the questionnaire forms and conduction of the expert evaluation in the on-line mode. This diagram presents the interactive conversational approach to solving problems of foresight in a unified information platform scenario analysis.

2. Example

Based on the proposed system approach to solving problems of foresight based on the Delphi method we consider a fragment of the information model of scenario analysis on the example of the situation of the livestock industry AIC Crimea (Fig. 4).

As of October 1, 2011 the livestock industry was in a state of crisis. During the first 9 months of 2011 in all categories of farms the reduction in the number of cows and milk production declines in gross were observed [9].

The problem of identification of the priority issues of the livestock industry, which led to a crisis in agriculture sector Crimea, is considered.

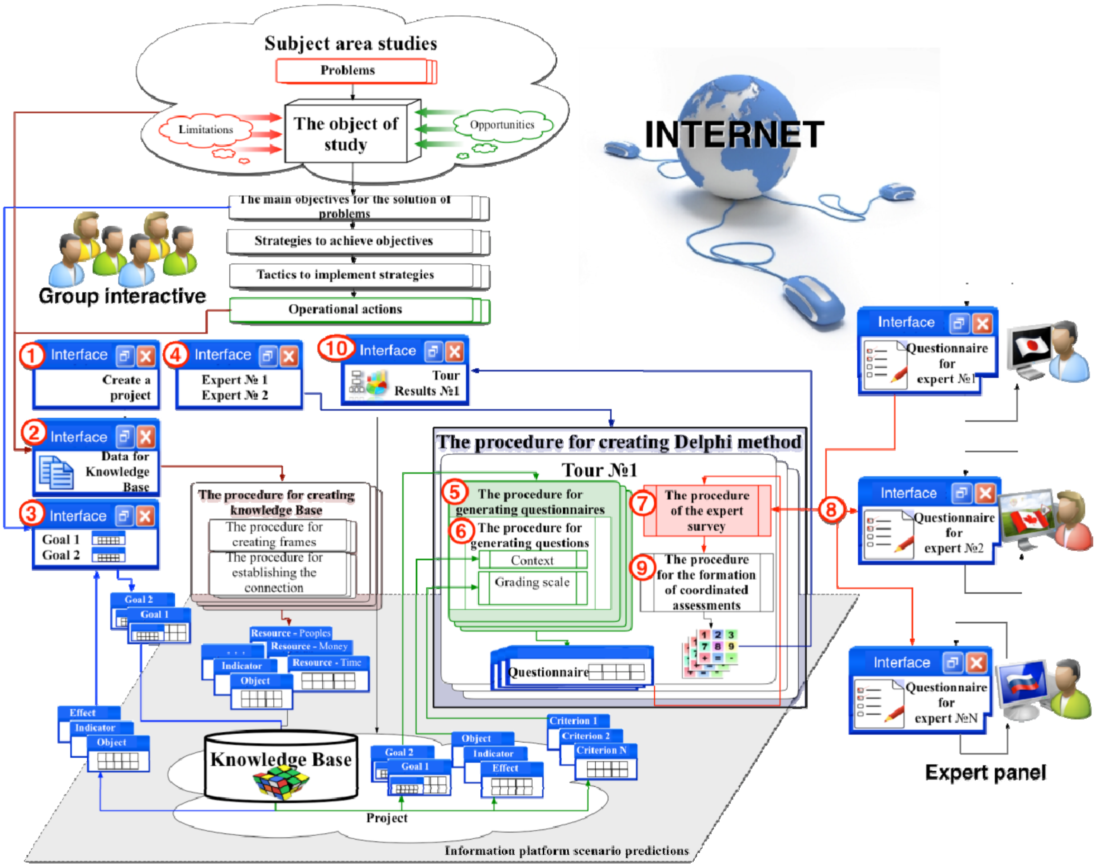

Figure 3. The block diagram of a strategy of system approach implementation in the on-line mode in the form of automated tools

Experts $E_{11}=\{E_{11k} \mid k=\overrightarrow{1,16}\}$ according to their levels of competence $\chi_{11}=\{\chi_{11k} \mid k=\overrightarrow{1,16}\}$, the values of which are presented in table 1 anonymously independently estimated object O_1 = “Challenges to overcome the crisis of the livestock industry" by criteria I_1 = “Priority” using a Miller scale with following levels $s=\overrightarrow{1,7}$:

1. The decrease in gross milk production ($x_1 \in [0;0,14]$);
2. Outdated milking equipment ($x_2 \in (0,14;0,24]$);
3. Unprofitability of the industry ($x_3 \in (0,24;0,43]$);
4. Reducing the proportion of forage crops ($x_4 \in (0,43;0,57]$);
5. Reduction in livestock ($x_5 \in (0,57;0,72]$);
6. Obsolete technical equipment ($x_6 \in (0,72;0,86]$);
7. Reducing the proportion of forage crops ($x_7 \in (0,86;1,00]$).

Thus, the generated question would be:

<u>The context of the question:</u>

Temporal boundaries: 2013-2015

Location: APK Crimea, livestock region

Object: The problems that led to the crisis

Indicator: Priority

Question:

Rate << Priority >> << breakdown-crisis of the livestock industry >> and confidence in the response for each level of << assessment scales >> in the context of the issue.

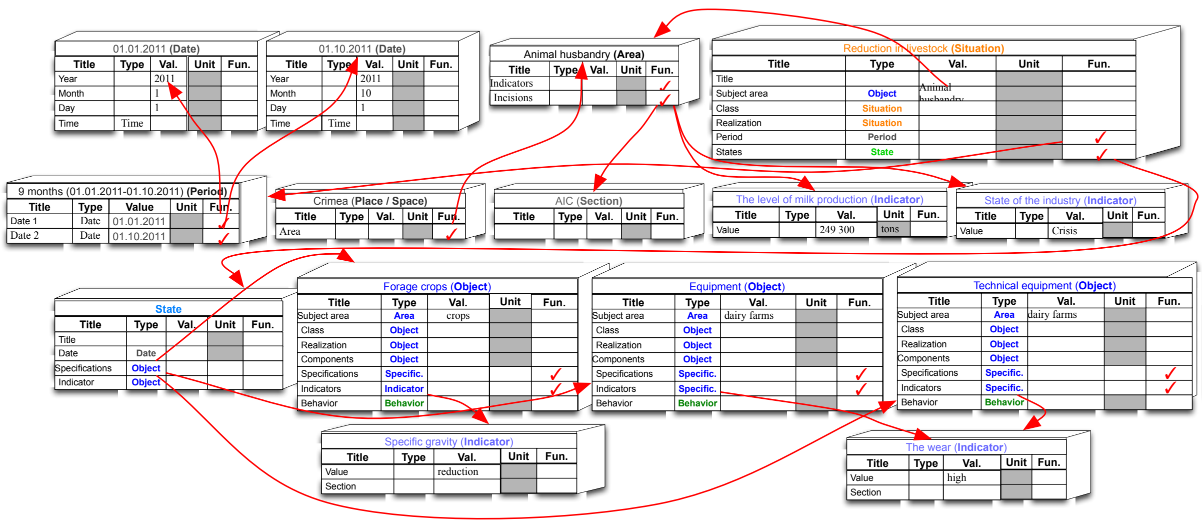

Figure 4. A fragment of the information model of prototype frames of livestock industry of Crimea

Table 1. Competence of experts

Експерт	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	№ 7	№ 8	№ 9	№ 10	№ 11	№ 12	№ 13	№ 14	№ 15	№ 16
χ_k	0,99	0,78	0,45	0,95	0,87	0,80	0,55	0,99	0,99	0,61	0,89	0,80	0,99	0,56	1,00	1,00

The resulting point estimates are shown in table 2.

Table 2. Point expert assessments

№	Експерт	s													
		1		2		3		4		5		6		7	
		μ_{11k1}	ν_{11k1}	μ_{11k2}	ν_{11k2}	μ_{11k3}	ν_{11k3}	μ_{11k4}	ν_{11k4}	μ_{11k5}	ν_{11k5}	μ_{11k6}	ν_{11k6}	μ_{11k1}	ν_{11k1}
1	Експерт 1	0,09	0,99	0,21	0,99	0,39	0,94	0,52	0,63	0,95	0,63	0,55	0,61	0,72	0,83
2	Експерт 2	0,13	0,94	0,31	0,61	0,57	0,94	0,79	0,94	0,83	0,99	0,66	0,94	0,40	0,61
3	Експерт 3	0,14	0,61	0,33	0,63	0,58	0,83	0,77	0,63	0,76	0,61	0,56	0,61	0,31	0,94
4	Експерт 4	0,65	0,63	0,82	0,99	0,71	0,83	0,46	0,83	0,23	0,61	0,09	0,94	0,03	0,63
5	Експерт 5	0,16	0,61	0,29	0,94	0,38	0,83	0,56	0,99	0,70	0,83	0,65	0,61	0,45	0,63
6	Експерт 6	0,59	0,61	0,85	0,63	0,93	0,83	0,76	0,83	0,47	0,83	0,22	0,61	0,08	0,83
7	Експерт 7	0,09	0,83	0,21	0,63	0,35	0,61	0,43	0,94	0,57	0,63	0,66	0,63	0,56	0,83
8	Експерт 8	0,63	0,83	0,84	0,83	0,77	0,63	0,53	0,99	0,27	0,61	0,11	0,63	0,03	0,61
9	Експерт 9	0,41	0,61	0,46	0,99	0,60	0,63	0,69	0,99	0,58	0,63	0,36	0,99	0,17	0,83
10	Експерт 10	0,27	0,63	0,53	0,94	0,80	0,94	0,90	0,99	0,77	0,94	0,50	0,83	0,24	0,83
11	Експерт 11	0,77	0,61	0,84	0,61	0,66	0,83	0,39	0,83	0,24	0,94	0,13	0,63	0,05	0,99
12	Експерт 12	0,10	0,99	0,25	0,83	0,47	0,61	0,64	0,99	0,65	0,94	0,50	0,63	0,39	0,61
13	Експерт 13	0,10	0,99	0,24	0,94	0,42	0,61	0,55	0,61	0,54	0,99	0,54	0,99	0,47	0,99
14	Експерт 14	0,05	0,83	0,11	0,63	0,25	0,63	0,52	0,94	0,78	0,94	0,87	0,83	0,74	0,63
15	Експерт 15	0,37	0,83	0,61	0,63	0,74	0,99	0,67	0,63	0,45	0,61	0,31	0,94	0,19	0,63
16	Експерт 16	0,90	0,61	0,84	0,83	0,57	0,61	0,29	0,61	0,15	0,61	0,07	0,63	0,02	0,83

The agreed expert assessment in accordance with the algorithm presented in Section 1.3 is formed. According to point estimates concerning (8) the interval expert estimates are constructed (table 3).

Table 3. Interval estimates of experts

№	Експерт	1			2			3			4			5			6			7		
		d^-_{11k1}	μ_{11k1}	d^+_{11k1}	d^-_{11k2}	μ_{11k2}	d^+_{11k2}	d^-_{11k3}	μ_{11k3}	d^+_{11k3}	d^-_{11k4}	μ_{11k4}	d^+_{11k4}	d^-_{11k5}	μ_{11k5}	d^+_{11k5}	d^-_{11k6}	μ_{11k6}	d^+_{11k6}	d^-_{11k7}	μ_{11k7}	d^+_{11k7}
1	Експерт 1	0,08	0,09	0,09	0,21	0,21	0,21	0,37	0,39	0,41	0,37	0,52	0,68	0,67	0,95	1,00	0,38	0,55	0,72	0,62	0,72	0,83
2	Експерт 2	0,12	0,13	0,13	0,21	0,31	0,40	0,54	0,57	0,59	0,75	0,79	0,82	0,82	0,83	0,84	0,63	0,66	0,69	0,27	0,40	0,52
3	Експерт 3	0,10	0,14	0,19	0,23	0,33	0,43	0,50	0,58	0,66	0,54	0,77	0,99	0,52	0,76	0,99	0,39	0,56	0,73	0,30	0,31	0,33
4	Експерт 4	0,46	0,65	0,84	0,81	0,82	0,83	0,61	0,71	0,81	0,39	0,46	0,52	0,16	0,23	0,29	0,08	0,09	0,09	0,02	0,03	0,03
5	Експерт 5	0,11	0,16	0,21	0,28	0,29	0,30	0,33	0,38	0,44	0,55	0,56	0,56	0,61	0,70	0,80	0,45	0,65	0,85	0,32	0,45	0,58
6	Експерт 6	0,41	0,59	0,77	0,60	0,85	1,00	0,80	0,93	1,00	0,66	0,76	0,87	0,40	0,47	0,53	0,15	0,22	0,28	0,06	0,08	0,09
7	Експерт 7	0,08	0,09	0,10	0,15	0,21	0,27	0,24	0,35	0,46	0,42	0,43	0,45	0,40	0,57	0,74	0,46	0,66	0,85	0,48	0,56	0,63
8	Експерт 8	0,54	0,63	0,71	0,72	0,84	0,95	0,54	0,77	0,99	0,52	0,53	0,53	0,19	0,27	0,36	0,08	0,11	0,14	0,02	0,03	0,05
9	Експерт 9	0,28	0,41	0,54	0,46	0,46	0,47	0,42	0,60	0,78	0,69	0,69	0,70	0,41	0,58	0,74	0,35	0,36	0,36	0,14	0,17	0,19
10	Експерт 10	0,19	0,27	0,35	0,51	0,53	0,56	0,76	0,80	0,83	0,89	0,90	0,91	0,74	0,77	0,81	0,43	0,50	0,57	0,21	0,24	0,28
11	Експерт 11	0,53	0,77	1,00	0,58	0,84	1,00	0,57	0,66	0,75	0,33	0,39	0,44	0,23	0,24	0,25	0,09	0,13	0,16	0,05	0,05	0,05
12	Експерт 12	0,10	0,10	0,10	0,22	0,25	0,29	0,32	0,47	0,61	0,63	0,64	0,64	0,62	0,65	0,68	0,35	0,50	0,65	0,27	0,39	0,51
13	Експерт 13	0,10	0,10	0,10	0,23	0,24	0,25	0,29	0,42	0,55	0,38	0,55	0,72	0,53	0,54	0,54	0,53	0,54	0,54	0,46	0,47	0,47
14	Експерт 14	0,05	0,05	0,06	0,08	0,11	0,14	0,18	0,25	0,32	0,50	0,52	0,55	0,75	0,78	0,82	0,75	0,87	1,00	0,52	0,74	0,96
15	Експерт 15	0,32	0,37	0,42	0,43	0,61	0,79	0,74	0,74	0,75	0,47	0,67	0,87	0,31	0,45	0,59	0,30	0,31	0,33	0,13	0,19	0,24
16	Експерт 16	0,62	0,90	1,00	0,72	0,84	0,96	0,39	0,57	0,74	0,20	0,29	0,37	0,10	0,15	0,20	0,05	0,07	0,09	0,02	0,02	0,03

To calculate the parameters of importance of expert assessments the Gaussian density is determined:

The mathematical average (2) of interval expert assessments is determined:

$$\overline{M}_{11} = \{[0{,}26;0{,}42],[0{,}40;0{,}55],[0{,}48;0{,}57],[0{,}52;0{,}66],[0{,}47;0{,}64],[0{,}34;0{,}50],[0{,}24;0{,}36]\}.$$

Calculate the integrated peer-review (3)

$$\overline{\overline{Q}}_{11} = \{[0{,}28;0{,}42],[0{,}43;0{,}56],[0{,}50;0{,}66],[0{,}52;0{,}68],[0{,}52;0{,}59],[0{,}35;0{,}54],[0{,}27;0{,}33]\}.$$

Calculate the correction factor for the valuation interval (4):

$$K^-_{11} = 2{,}55 \;;\; K^+_{11} = 1{,}94 .$$

A Gaussian density is determined (5) with the normalization factor:

$$\widetilde{Q}_{11} = \{[0{,}20;0{,}28],[0{,}35;0{,}47],[0{,}48;0{,}64],[0{,}52;0{,}68],[0{,}45;0{,}58],[0{,}31;0{,}40],[0{,}17;0{,}21]\}.$$

Indicators of importance according to (1) have the following meanings:

$$w_{11}(\overline{Q}_{11.1}) = 0{,}68 \quad w_{11}(\overline{Q}_{11.2}) = 0{,}60 \quad w_{11}(\overline{Q}_{11.3}) = 0{,}36 \quad w_{11}(\overline{Q}_{11.4}) = 0{,}66$$
$$w_{11}(\overline{Q}_{11.5}) = 0{,}67 \quad w_{11}(\overline{Q}_{11.6}) = 0{,}58 \quad w_{11}(\overline{Q}_{11.7}) = 0{,}40 \quad w_{11}(\overline{Q}_{11.8}) = 0{,}69$$
$$w_{11}(\overline{Q}_{11.9}) = 0{,}86 \quad w_{11}(\overline{Q}_{11.10}) = 0{,}49 \quad w_{11}(\overline{Q}_{11.11}) = 0{,}59 \quad w_{11}(\overline{Q}_{11.12}) = 0{,}65$$
$$w_{11}(\overline{Q}_{11.13}) = 0{,}80 \quad w_{11}(\overline{Q}_{11.14}) = 0{,}35 \quad w_{11}(\overline{Q}_{11.15}) = 0{,}84 \quad w_{11}(\overline{Q}_{11.16}) = 0{,}64$$

The least remote expert assessment is found by the algorithm presented in Section 1.3:

The distance matrix (7) between the estimates of the experts is constructed:

$$D_{11} = \begin{matrix} Expert1 \\ Expert2 \\ ... \\ Expert15 \\ Expert16 \end{matrix} \begin{bmatrix} 0,00 & 0,22 & ... & 0,41 & 0,65 \\ 0,22 & 0,00 & ... & 0,33 & 0,56 \\ ... & ... & ... & ... & ... \\ 0,41 & 0,33 & ... & 0,00 & 0,37 \\ 0,65 & 0,56 & ... & 0,37 & 0,00 \end{bmatrix}.$$

A vector (8) from the respective rows of the resulting matrix is calculated:

$$S_{11} = [7,67 \quad 7,04 \quad ... \quad 7,07 \quad 8,44].$$

The value of expert estimate, which is less remote from the opinions of other experts (9), which corresponds to the expert number 13, is found:

$$M_{11} = Expert\,13(6,36).$$

In the confidence set T_{11} , calculated using (10), taking into account $R_1^{(T_{11})} = 0,25$, the experts № 1, № 2, № 4, № 5, № 6, № 8, № 9, № 11, № 12, № 13, № 15, № 16 are included. Indicator of the level of consistency (11) $S^{(T_{11})} = 0,75$, which is greater than a predetermined threshold priori $S^* = 0,7$, indicates the consistency of expert estimates in this round of expert evaluation.

The point estimate with the greatest ability to implement and with the maximum degree of confidence in the supplied reply corresponds to the level $s(Q_{11}) = 6$.

Thus, most experts agreed that "Outdated technical equipment" is the main cause of the crisis of the livestock industry of AIC Crimea and all major powers to combat the crisis should be aimed at elimination this problem.

3. Conclusion

Under the conditions of rapid development of innovative technologies the application of system approach to solving problems of foresight is a necessary component for the effective support of the process of foresight.

The information model of knowledge is a flexible toolkit for building, reporting and analysis of alternative scenarios for the future in the visual form for analytics with the purpose of further analysis and appropriate recommendations to assist in making a decision.

The application of a combination of frames and the semantic network has advantages in the description of objects, processes, events and scenarios in the database with the time-space dimension and representing each of them as an integral structure - a frame. The establishment of the forward and backward connections between the entities with the help of other entities raises the level of perception of the information by the analyst, provides a convenient machine representation for analysis and prevents the violation of structural uniformity and integrity of the database.

The architectural approach to the representation of the field of knowledge in the form of framing allows the network to scale objects to appropriate levels, allowing them to contrast and compare with each other by various sections [2]. Presentation of tier architecture according to the principle of abstraction the knowledge field makes it possible to move from a linear planar representation of complex entities to more simple, which allows you to create an ordered hierarchy of knowledge, taking into account the features of the process of foresight.

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