INFORMATICA, 1992, Vol.3, No.3, 393–417

DATA RELIABILITY PROBLEMS FOR IMPARTIAL MULTICRITERIA DECISION SUPPORT

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Abstract. Some exceptional features of the dynamically changing environment require the additional means for qualitative knowledge representation, data verification and ensurance of operativity of decision making processes. The article considers the possibilities of integration the safequard methods for impartial multicriteria decision making with the three levels of knowledge representation distinquished in the decision support system (DSS). The approach is to represent static and dynamic aspects of the target system and to reflect them in deep knowledge representation level. The means to formalize multiple objective decision making mechanisms is proposed. The examples developed during the designing stages of the ecological evaluation system for different enterprises demonstrate the results of using extended E-nets for modeling cognitive processes leading to decisions.

Key words: decision support system (DSS), deep knowledge representation, dynamic modeling, temporal aspects, E-nets.

1. Introduction. The problems of data reliability in the DSS in order to ensure the correct and impartial decisions in a dynamically changing environment are of the same level of importance as knowledge aquisition and qualitative knowledge representation. The great amount of measurement points and operative changability of the situation in a certain time period causes the uncertainty of measurements and reports, the investigation of partial information and so on. In this case the overlapping and conflicts are possible between different observations. Decision making is performed considering a lot of various factors, evaluating the monitoring data and comparing the reports and the real situation, etc. A wide range of the information requires the special methods for dynamical observation of the situation, data verification as well as representation of the operativity in DSS.

The existence of polysemantic knowledge requires the use of several methods for knowledge representation in the same system. The orientation towards model-based rule learning approaches for knowledge acquisition, caused by the qualitative deep representation of knowledge provided by a semantic model, allows to represent the domain specificity more expressively and to choose the main, principles and rules used firstly. This deductive approach bypasses an ordinary and multiple modeling which is used to obtain the rules from the examples. It also enables to deduce the mechanism of operative decision making more efficiently. It is possible to detect the knowledge formed by the contextual domain investigation modes. This is the level of conceptual representation of entities, processes, situation by concepts (basic elements) of the domain. Another level is the representation of expert empirical knowledge provided by practical experience and the actions of leading specialists of the domain. The problem specifying statical and dynamical aspects of the enterprise system and the information system has arisen and it has been discused by many authors during the recent decade. The actual contribution to modeling of statical and dynamical aspects of information and to proposed conceptual schemes was made by Brodie and Silva (1982), Casanova *et al.*(1983), Rolland *et al.* (1982, 1984) in REMORA methodology, Bussolati *et al.* (1983) in DATAID project. Modeling is considered to be a complex and important process especially in the first phases of the system development if we orient ourselves towards modeling support tools as it is presented by Wijers *et al.* (1991). Information modeling is that part of requirements engineering which has to deal with interaction, incompleteness and heuristic ecpecially at the first stages of the system development.

We are considering the possibility of representation of rules and their dynamic control and connection of the output mechanism with temporal attributes based on the extension of Petri nets, called evaluation nets (E-nets) described by Noe and Nutt (1973). E-nets notation, extended by some temporal parameters (Dzemydienė, 1986, 1988; Dzemydienė and Baskas, 1990) is used to represent dynamics with respect to explicit temporal aspects of the target system. The temporal knowledge representation aspects are of primary interest in the DSS context when the problems of retrospective analysis and prognosis are concerned. In the prognosis of the further evolution of target area and the system behaviour it is important to design adequate imitation model of the system. The attempt to join the E-nets and means of imitation simulation is made by Pranevitchius and Švanytė (1980) and Pranevitchius and Dzemydienė (1980). A variety of temporal representation approaches for specifying events in the DSS context suggested such as historical models by Clifford and Warren (1983), Ariav (1986); date line models by Kahn and Gorry (1977), Gustafsson *et al.* (1988), Gadia *et al.* (1988); models represented as before/after chains by Kahn *et al.* (1977), Hennessy *et al.* (1985); interval based models by Allen (1983), De, Pan and Wingston (1987), cover many aspects of the given phenomenon specificity.

The rule forming and control by evaluating various decision making mechanisms of different experts are related with the problem of rule specification and lies in the fact that the behavior models of the person making the decision are not complete, the context rules are specific, sometimes contradictory. Some aspects of safeguarding for impartial and correct multicriteria decision making are considered in the article.

2. Extension of the E-net notation. An E-net as represented by Noe and Nut (1973) is a connected set of locations over the set of allowable transition schema, and is denoted as the following four-tuple $E = (L, P, R, A)$. It is possible to consider the net as the relation of $(E, M., \Xi, Q, \Psi)$, where L is a nonempty set of locations $\{b_j\}$, where P is the set of peripheral locations $\{p'_j, p''_j\}$, where $\{p'_j\}$ are input peripheral locations and $\{p''_j\}$ are output peripheral locations, R is the set of resolution locations $\{r'_i, r''_i\}$; A is a finite, nonempty set of transition declarations $\{a_i\}; M_0$ is the initial marking of the net; Ξ is the set of token parameters; Q is the set of transition procedures $\{q_i\}$; Ψ is the set of procedures of resolution locations $\{\psi(r_i'), \psi(r_i'')\}$. An E-net transition denoted by Noe and Nutt (1973) as $a_i = (s, t(a_i), q_i)$, where s is a transition scheme, $t(a_i)$ is a transition time and q_i is a transition procedure. To represent temporal aspects a transition description is extended as follows:

$$a_i = (L_i'[\{\xi_j\}_i], L_i''[\{\xi_j\}_i], r_i', r_i'', \psi(r_i', r_i''), q_i, t_i^p, \tau_i, t_i^f, \Pi t_i, st_i),$$

where i is an index of transition, L_i' is the set of input locations of the transition $\{b_j'\}_i$, where $j = \overline{1,n}$, n is a number of input locations, L_i'' is the set of output locations of the transition $\{b_j''\}$, where $j = \overline{1,m}$, m is the number of output locations; $L', L'' \in L; r_i'$ is the location of complex conditions on the input of transition (i.e., resolution location); r_i'' is the resolution location for the output of transition; t_i^p is a planned moment of transition firing, $t_i^p \in T^*$, where $T^* = TU\{t^*\}$; T is the absolute time scale, $\{t^*\}$ are time moments which are determined approximately (i.e., not fixed beforehand); t_i^f is a factual moment of transition firing; τ_i is the duration of the transition work; Πt_i is the periodical transition time; $q_i \in Q$ is a procedure, which according to the rules of transition work realizes a reflection of $MX\xi'XL'XL''XT^*XR$ to ξ'' and determines the tokens $m \in M$ flow with parameters $\{\xi'\}_j$ from input locations $\{b_j'\}$ to output locations, taking into account the functions of resolution procedures $\psi(r_i'), \psi(r_i'')$ at the actual time moment t_i^f, which at the current time moment is compared to the real time moment in the absolute time scale $t_c \in T$; st_i is the specification of temporal relationships of transition with other marked time moments.

The general view of the transition scheme is shown in Fig. 2.1.

The possibility of dividing resolution locations into input and output of the transition allowed to unite the situation of choosing the locations for input as well as for output of the same transition.

The procedures of complex conditions for transition input $\{\psi(r_i')\}$ allow to specify the transition firing dependence on:

– the combination of factors of the previous transitions accomplishment;

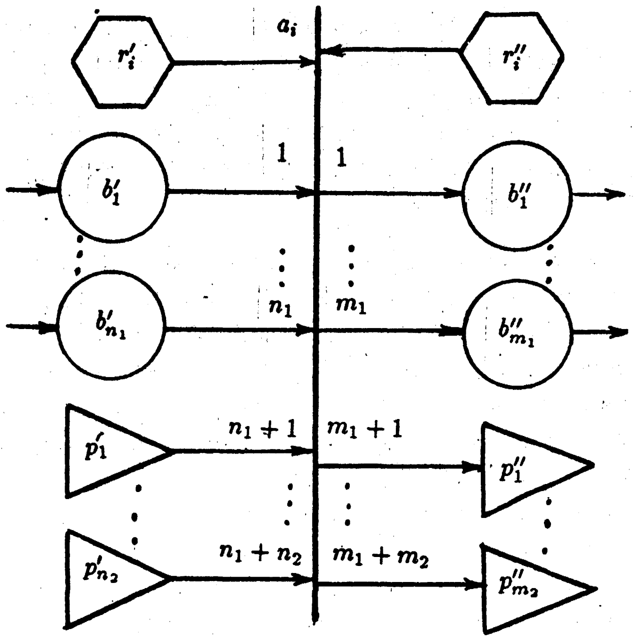

Fig. 2.1 The general view of the extended E-net transition scheme.

– the combination of concrete parameters of tokens meanings;

– the combination of the meanings of external conditions.

The procedures of complex conditions for transition output $\{\psi(r_i'')\}$ allow to specify :

– the combination of choice of the tokens flow into output locations for the transition completion ;

– the combination of choice and/or determination of the dependence of output attributes $\{\xi_k''\}$ and/or external parameters of token meanings $\{p_j'[\xi_k]\} \in P$.

The temporal parameter $t_i^p \in T^*$ allows to control the net not only automatically but also according to the planned terms. The temporal parameter $t_i^f \in T$ allows to fix the factual moments of transition firing which are directly related with the evaluation of the events described by the given net fragment according to time. The abstract conception of specification of the temporal relationships allows to concretely by evaluate the event described by the given transition regarding other marked time moments. It will allow to formalize those aspects of the decision making mechanism which are necessary to determine the situation of events (tasks, operations, etc.) accomplishment.

3. Qualitative knowledge representation in the DSS. Some issues for a qualitative knowledge representation including the aquisition and structurization stages are considered in this section. Our universe of discourse (UoD) is concerned with decision making which is aimed at the evaluation of ecological situation of the region. The industrial, agricultural and similar enterprises that pollute or can potentially contaminate territorial waters and air are essential objects for analyzation. The decision making is aimed at the permission of further exploitation or building new objects that pollute or can potentially contaminate surroundings and is related with the problems of estimation of a general ecological situation in the given region, all indices of pollution provided in the project of the object, risk factors related with the preservation of links that are of biological significance in dependence of time and so on.

We have distinguished three levels of representation in this system: deep knowledge, analyzed the behavior of the enterprise system and decision making processes. The scheme of interaction of these levels is shown in Fig 3.1. Here (A) is the level of statical aspect representation.

The knowledge is revealed by contextual foundations of the UoD study. The semantic model is under construction which expresses qualitative features of the entities, processes and their life cycles, relationships between entities, the degree of agregation and hierarhy. The organizational principles of the UoD are achieved by a semantic submodel of static components and are constructed by using three types of abstractions between the chosen entities (aggregation, generalization and transformation) described by Kangassalo (1984). This is the scheme of "workspace" of the working memory. An example of the statical submodel of relationships be-

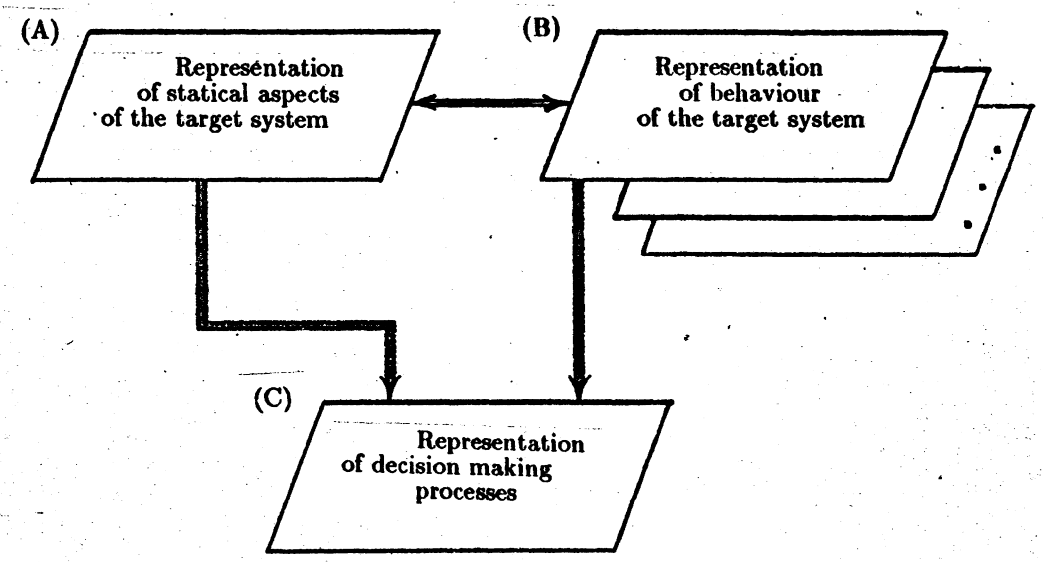

Fig. 3.1. Intersection between three levels of knowledge representation in the DSS.

tween entities is represented by a structural functional scheme of concepts for water distribution (Fig. 3.2.)

The level of representation of dynamical aspects (B) shows the dynamics of observable processes in the enterprise system. At the stage of deep knowledge representation we construct a dynamical submodel of the behavior not for the general enterprise system but only for the chosen information units which are semantically sufficient for the analysis. The question arising in the design is a semantic evaluation of information which is sufficient to ground different conclusions. Another one is the selection of the forms of information representation and of the order of conclusions for different groups of specialists. The information units, the analysis of which as well as the results of the analysis, play the main part in choosing the decision, are distinguished and reflected.

The harmful materials, their usage and distribution during the production process are those chosen information units the dynamics of which we have to analyze for basic conclusions on the extent of the object contamination. The dynamic submodel is designed by using a E-nets at various levels of detailing. The E-net of the distribution of harmful materials in the object is shown in Fig. 3.3.

A semantic description of this net: the raw materials ($p_1, \ldots, p_{1,n}$) are received from the suppliers and are registered in the supply department of the object (a_1). These raw materials ($b_1, \ldots, b_{1,n}$) may be distributed (a_2) in the internal system of the object as follows: one part of the materials ($b_2, \ldots, b_{2,n}$) may be left in the storehouses or open in the object territory (a_4), another part ($b_4, \ldots, b_{4,n}$) may be delivered directly into the production technological processes (a_7) and third part is rejected as ($b_3, \ldots, b_{3,n}$) defective materials. The defective materials may be distributed (a_3) as follows: one part of these defective materials ($b_5, \ldots, b_{5,n}$) may be left in the storehouses or open in the object territory (a_4), a second part ($b_6, \ldots, b_{6,n}$) may be preprocessed (a_6) before getting into production, a third part ($b_7, \ldots, b_{7,n}$) may get directly into production technological processes, a fourth part ($b_3, \ldots, b_{3+n}$) may be returned to suppliers. During the production technological processes (a_7) the materials

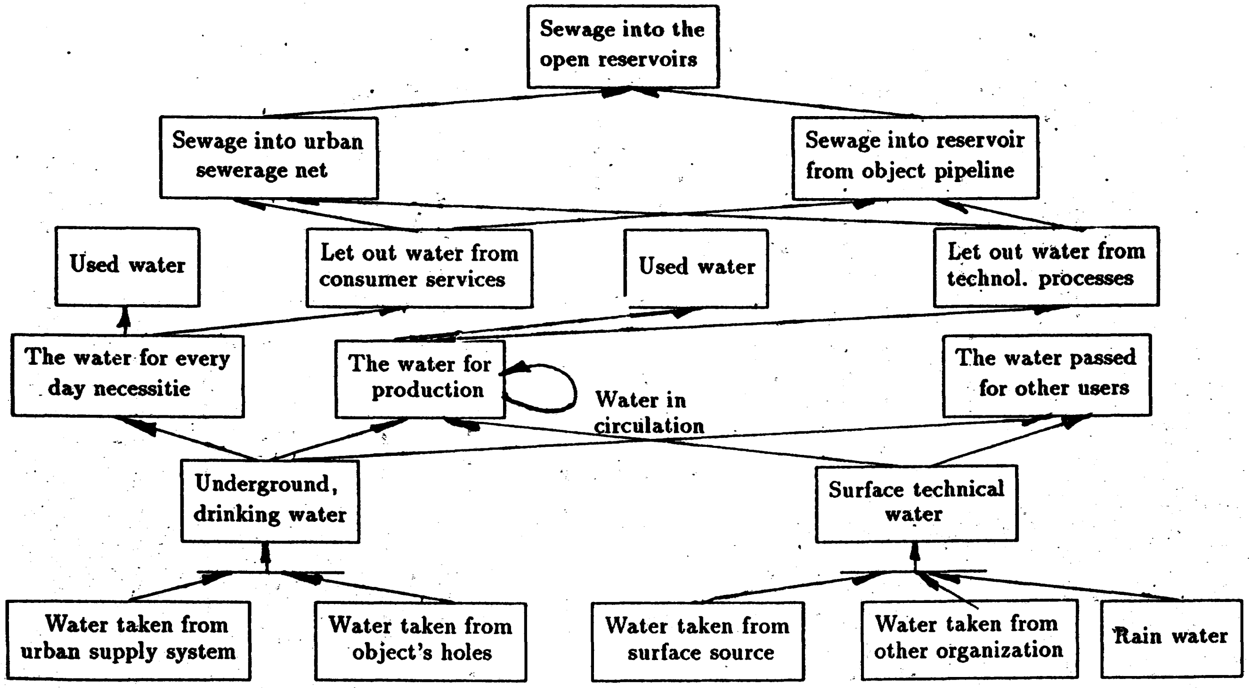

Fig. 3.2. The statical submodel of relationships between the entities according to the water distribution.

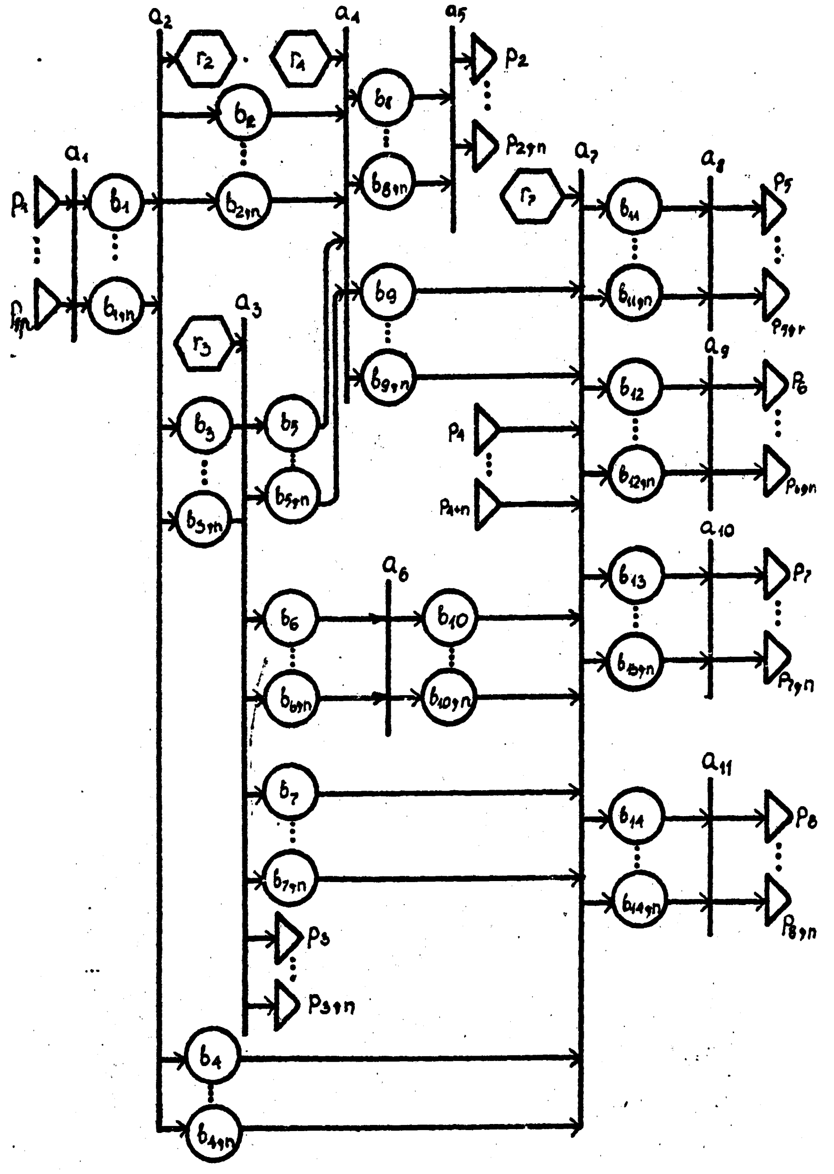

Fig. 3.3. The *E*-net of distribution of harmful materials in the object.

may be distributed as follows: one part ($b_{11}, \ldots, b_{11,n}$) is used for the ready or half-ready products (a_8), another part ($b_{12}, \ldots, b_{12,n}$) is thrown out into the air (a_9), a third part ($b_{13}, \ldots, b_{13,n}$) is thrown out into the water (a_{10}) and a fourth part ($b_{14}, \ldots, b_{14,n}$) may form as waste materials (a_{11}). In the case they stay in the storehouses or open they are evaporating, are spilt or washed away with rain water (a_5).

Different levels of detailing of these processes are distinguished using macro transitions. The decomposition of transition a_{10} (the processes of distribution of the harmful materials in the water) is shown in Fig. 3.4.

The semantic description of the output locations:

$p_8, \ldots, p_{8,n}$ are waste materials from the primary sewage purification plant;

$p_9, \ldots, p_{9,n}$ are waste materials from the common sewage purification plant;

$p_{11}, \ldots, p_{11,n}$ are materials getting into open reservoirs, if there is no rain water assembling system;

$p_{12}, \ldots, p_{12,n}$ are utilized wastes;

$p_{10}, \ldots, p_{10,n}$ are materials getting into open reservoirs, which are not detained in the sewerage system of the object;

$p_{14}, \ldots, p_{14,n}$ are materials getting into external reservoirs from the leakage pipes of the object;

$b_{22}, \ldots, b_{22,n}$ are materials settling in rain water assembling system.

The semantic description of the transitions:

a_{10} denotes getting of the harmful materials with sewage into the sewerage system;

a_{12} is the urban sewerage system;

a_{13} is washing out by rain water;

a_{14} is the rain water assembling system;

a_{15} is a common sewage purification plant of the urban sewerage system;

a_{16} is detaining/settling in the primary sewage purification plant;

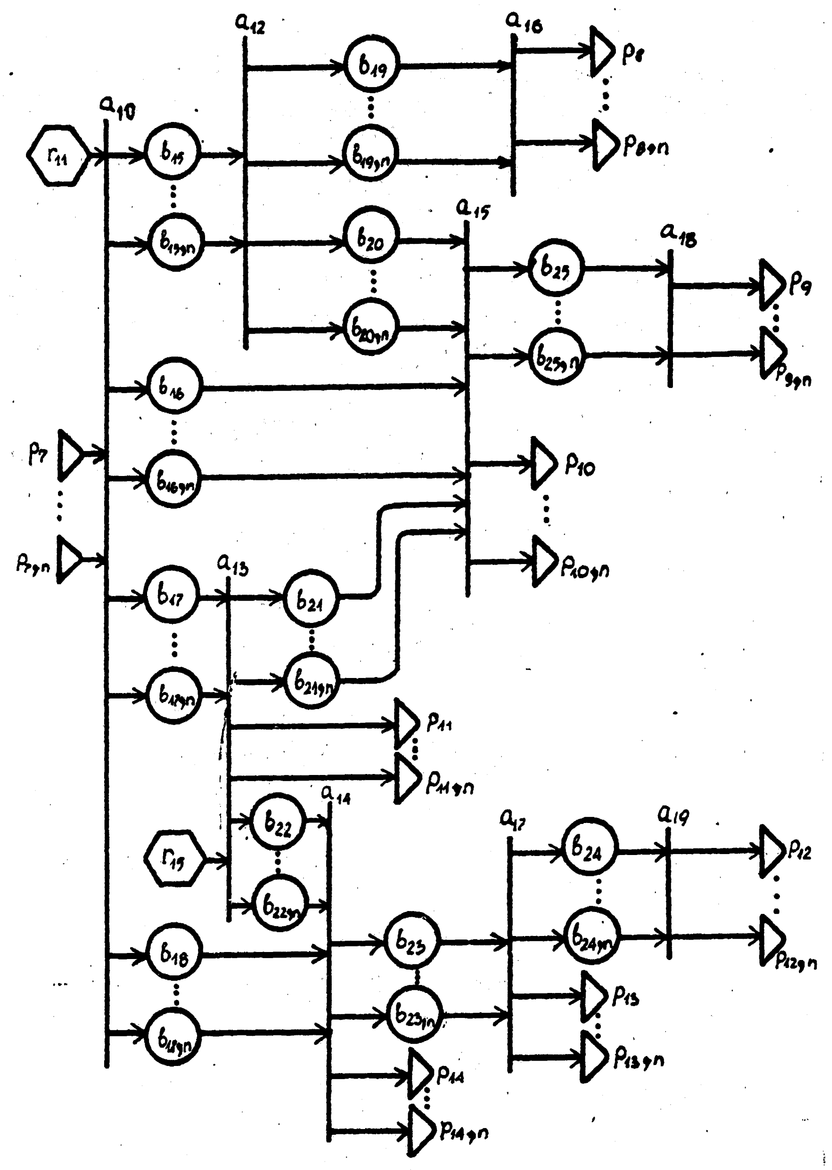

Fig. 3.4. The E-net of distribution processes of the harmful materials in the water.

a_{17} is a primary sewage purification plant;

a_{18} are the leakage pipes of sewage;

a_{19} is the utilization of waste.

The dynamical submodel is the result of a systematic analysis and explicitly represents all possible cases of distribution of the materials and enables to foresee all this cases for the balance and inspection task solving. The multiple objective decision making (C) deals with the analysis of information obtained from the statical submodel taking into account all possible measurement points revealed in the dynamical submodel of such a system. The modelled system is regarded as a direct mapping of the real enterprise system, and decisions can be based on the decisive facts and follow rather deterministic rules. The real enterprise system can be considered as a mixture of conflicts and cooperation, while the system being designed has support the negotiation mechanism.

4. Integration of the representation of multicriteria decision making with safequard means for impartial decision support. In the dynamically changing environment decision making usually means multiple objective decisions based on partial information. The programs have some dificulties in dealing with past and future events, i.e., in establishing what is actually true at present and what can be true in future, and what action at a certain time will change the state of the system. We must include the selection mechnisms of appropriate rules and their possible switch as decision evolves. In this case the formalization of decision making processes must include the representation of dynamics of all inference mechanisms, all points of observations, all criteria which are semantically sufficient for making the decision in appropriate time moment. The possibility of applying the E-net notation for specification of the inference mechanisms (Dzemydienė, 1992) allows to interpret the rules by the set of transitions $A = \{a_1, \dots, a_n\}$ of E-net. The locations $L = \{b_1, b_2, \dots, b_m\}$ will correspond to the conditions (facts), so that the condition of applicability of each rule consist in simultaneous accomplishment of a certain totality of conditions $\{b_{i_1}, \dots, b_{i_s}\}$. Each condition from the given totality may be a compound vector $\vec{b}_{ik}$, i.e., may consist of the set of elementary conditions; $\vec{b}_{ik} = \{b_{ik}(\xi_{j1}), b_{ik}(\xi_{j2}), \dots, b_{ik}(\xi_{jn})\}$.

The situation of rule applicability is determined by various combinations of accomplishment facts of elementary conditions. The fact of condition $M(\vec{b}_{ik}) = 1$ means that the token is in the location b'_{ik} and is a confirmation of this condition. Inference of state $M(\vec{b}_{ik}) = 1$ is the evidence of the statement: $B = M(b'_{ik}(\xi_{j1})) \wedge M(b'_{ik}(\xi_{j2})) \wedge \dots \wedge M(b'_{ik}(\xi_{jn})) = 1$.

A transition without a resolution location describes the situation of applicability of the rule as: $M(\vec{b}_{i1}) \wedge \dots \wedge M(\vec{b}_{is})$. The transition having a resolution location r' allows to describe the situation in the following way: $M(\vec{b}'_{i1}) \vee \dots \vee M(\vec{b}_{is})$ or to apply various combinations of conjunctions and disjunctions between $M(\vec{b}'_{ik})$.

The result of the rule may be determined either by the combination of the facts of condition accomplishment making an impact for an other rule or the final inference. The purpose of the work of this system is finding the sequence of the rules inferring the fact we are interested in. The net allows to represent various procedures of forming the sequences of rules that may include consecutive, recurrent, parallel or mixed inferences. Each rule in an inference sequence establishes a new fact. Established at a certain moment of inference, a collection of facts may be considered as the state of DSS, and the rule as the operator changing this state. The state under consideration may be defined by the vector:

$$\vec{M}_i = \{M_i(\vec{b}_j),\ M_i(\vec{b}_{j+1}), \dots, M_i(\vec{b}_{j+N})\}, \tag{4.1}$$

where N is the number of positions belonging to a certain fragment of the net under consideration. Each of $M_i(\vec{b}_{j+s})$ may be equal to 1, if the fact is determined at a given time moment t_i (i.e., the token is placed in the position b_{j+s}), or equal to 0, otherwise (i.e., there is no token in the position b_{j+s}).

The whole inference process may be described as the evolution of the dynamic system:

$$\vec{M}_{i+1} = a_{ti}\vec{M}_i, \tag{4.2}$$

where $\vec{M}_i$ is the state before the moment t_i, a_{ti} is the rule applied at the moment t_i, $\vec{M}_{i+1}$ is the state after the rule application. Assume that the system may remain constant in a certain time interval with regard to the facts being inferred. Thus, it is possible to mark all states $\vec{M}_{i-1} < \vec{M}_i$ which where inferred before the moment t_i. These states may be called as logical consequences of the state $\vec{M}_i$.

The system (4.2) is controlled regarding time because the rule may be chosen from the set A at an appropriate time moment. The terminal or objective set of states will be interpreted by the set of output (terminal or peripheral) locations $\{p_j''\}$.

From the point of view of dynamic description (4.2), the purpose of inference will be achieved if $M(\vec{p}_j'') = 1$, i.e., the state is achieved:

$$M(p_j''(\xi_{j1})) \wedge M(p_j''(\xi_{j2})) \wedge \ldots \wedge M(p_j''(\xi_{jn})) = 1, \tag{4.3}$$

where ξ_{jk} are the parameters of the token which has come to the location p_j''.

It is possible to determine the set of final inferences $\{p_j''\} = P'' \subset P$ as a discrete set of decisions or alternatives (variants) exposed for choice. The complexity of the decision making task consists in fiding the best decision in conditions of multicriteria. The number of alternatives increases applying multicriteria evaluation and it is necessary to choose the mechanism of rejecting a number of those alternatives. Analyzing the possibilities of choice mechanisms (under the lack of information about the importance of criteria or the criteria are equivalent) the acceptable decision variant seems to be not so easily chosen. It is expedient to make a choice according to the weighed criterion. The base for choosing the decision variant is qualitative information on the relevant importance of a separate criterion. In real choice tasks the variants are not in the arbitrary order: some variants may exclude the other ones, while the other are always accompanied. The set of criteria functions or certain criteria is denoted as $g^* = \{g_1, g_2, \ldots, g_n\}$. The f function allows to depict the set of admissible decisions in the set of vector estimations. The estimation of the variant $g_k(p_i'')$ according to the criterion g_k is designated by $p_i''(\xi_k)$. We call the collection $\tilde{p}_i'' = (p_i''(\xi_1), \ldots, p_i''(\xi_d))$ as the vector estimation of the variant p_i''.

The choice according to the weighed criterion g_k, $k = \overline{1,d}$, is based on the weight $w_i \geqslant 0$ estimation characterising their importance. The choice function

$$C_{\tilde{w}}(P'') = \{p_i'' \in P'' | (\forall p_j'' \in P'')((\tilde{w}, \tilde{p}_i'') \geqslant (\tilde{w}, \tilde{p}_j''))\}$$

is formed by the variants with the maximum weighed sum:

$$\sum_{1 \leqslant k \leqslant d} w_k p_i''(\xi_k) = (\tilde{w}, \tilde{p}_i''), \quad \tilde{w} = (w_1, \ldots, w_d).$$

The E-net structure, which describes the decision making process in dynamics, visually gives the parameters needed for control, control structure relation with the tasks and decisions (see Fig. 4.1). The decision is realized in the procedure of resolution location in which the values of parameters for comparison and comparison relations, its variants and the weights of separate criteria estimation are determined.

The extention of E-net notation with temporal parameters enables us to include time attributes such as time moments and time intervals for each component of the observable information and the inspection data. Some supplemental methods for revealing of the more exact information of observations and supporting negotiations must be included in DSS. Some deterministic rules and parallel calculations are introduced for reliability of the observed and checked processes to exclude some falsifications of the reported data. For the variant of one rule, which determines the frequency and type of sewage water control estimation see Table 4.1.

The water of the object is evaluated according to the use of water resources and sewage contamination. The semantical description of transitions of the E-net in Fig. 4.1. is:

U.1. In the object the balance of used water and the dynamics estimation task consists of:

U.1.1. The ratio between the permissible amount of underground water resources and the used water;

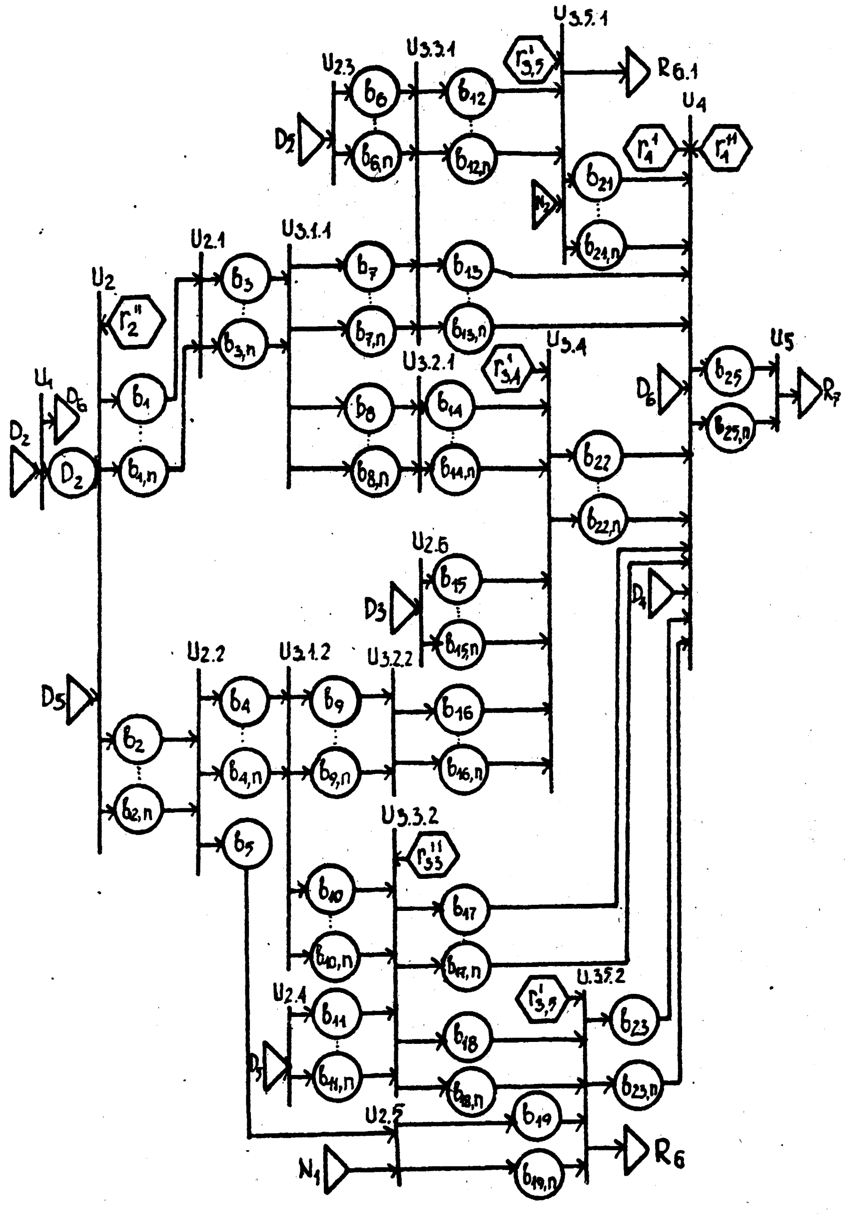

Fig. 4.1. The *E*-net of decision making processes for ecological evaluation of water pollution.

Table 4.1 A sample of rule for determining systematic analysis of sewage

IF			THEN	
Sewage			Frequency of sewage analysis	Character of analysis
Character	Let out amount of sewage Q			
	Let out into the urban net	Let out into open reservois		
	m^3/in day	m^3/in day		
from industrial technological processes	$Q > 500$		once a month	common analysis and specific obligatory materials are determined
	$10 < Q < 50$		once in a quarter	
	$Q < 100$		the analysis not carried out	
		$Q >= 100$	once a month	extended analysis
		$Q < 100$	once in a quarter	extended analysis
Water from consumer services	$Q > 500$		once a month	dynamical characteristic of separate specific materials
	$500 < Q < 100$		once in a quarter	
	$Q < 100$		once in a quarter	average contamination characteristic
Rain water				
Mixed water				

U.1.2. The permission to use natural water resources by the object;

U.1.3. The balance of aguired, used, passed over and sewage water in the internal object system;

U.1.4. Comparision of the used water resources dynamics in different periods.

U.2. Determination of systematic analysis rules of sewage contamination:

U.2.1. Analysis of contamination of sewage thrown in to the urban sewerage net;

U.2.2. Analysis of contamination of sewage thrown in to the object sewerage system;

U.2.3. Inspection of sewage in the urban sewerage net;

U.2.4. Inspection of the object sewerage system;

U.2.5. Determination of the type of water reservoir;

U.2.6. Determination of the balance of the materials distribution.

U.3. The task of sewage contamination analysis consists of:

U.3.1. Determination of the average proportional concentration of harmful materials according to the data on the average proportional characteristic and dynamic one of contaminated sewage (for each separate pipeline);

U.3.2. The amount of harmful materials during a certain period, evaluating a changeability of measuments (i.e., the average squared divergence and error of calculation);

U.3.3. Comparison of the control measurements of the harmful material amount with the results of task U.3.2;

U.3.4. Comparison of material distribution balance data to the harmful material amount characteristic (received in U.3.2);

U.3.5. Determination of sewage contamination according to the greatest permissible concentration (GPC) norms for separate types of receivers.

U.4. General evaluation of the object according to water resource usage and sewage contamination.

The decision results of U.4 are input data for environmental damage estimation in the "Inspection" subsystem.

Semantical description of locations used as information units:

D.1. The data on sewage contamination inspection.

D.2. The data on a primary account of used water.

D.3. The data on the harmful material distribution balance taking into account the received raw materials and ingredients of formed harmful materials thrown into water.

D.4. The existing and planned means for rational use of water resources and protection from contamination.

D.5. The data on a systematic analysis of sewage contamination.

D.6. The data on water resources.

N.1. Norms of contamination of the underground water resources.

N.2. Norms of sewage characteristic of the common sewage net.

In Fig. 4.1 the E-net obviously shows one of variant of decision making processes and represents the relationship between tasks, parameters, and decisions for evaluating the sewage contamination level.

The set of data used for verification must contain significant episodes of the performance of enterprise system under critical conditions and under normal circumstances. The algorithms for calculation of average proportional values of data from observations of contradictory situations are included. The average proportional concentration of harmful materials calculated according to the data of average proportional characteristic of contaminated sewage is given as an example in the case when the proportional samples of sewage are analyzed:

$$C^i_{av} = \frac{C^i_1 q_1 + C^i_2 q_2 + \ldots + C^i_n q_n}{q_1 + q_2 + \ldots + q_n} [mg/l],$$

where $C^i_1, C^i_2, \ldots, C^i_n$ are concentrations of separate harmful material i established in each sample, $j = 1, 2, \ldots, n$ is number of samples, $q_1, \ldots, q_n$ are amounts of water during the sample construction time.

The average proportional concentration of the certain time interval determined for separate harmful materials as well

$$C_\Delta^i = \frac{\sum_{j=1}^n C_{av,j}^i \cdot Q_j}{\sum_{j=1}^n Q_j}[mg/l],$$

where $Q_1, Q_2, \ldots, Q_n$ denote the amounts of water flowing through the pipeline in separate days when the samples were taken for analysation.

The average amount of harmful materials during a certain time interval, evaluating a changability of measurements is revealed by

$$S_{av}^i = C_\Delta^i \cdot Q_\Delta,$$

where Q_Δ denote the amount of water flowing through the pipeline during this time interval.

4.1. Formal description of decision making processes for evaluating the sewage contamination level. The purpose of this section is to illustrate the specifications of a net that can be interpreted by computer.

Semantical description of the set of attributes:

ξ_1 is the amount of sewage let out into the urban net;

ξ_2 is the amount of sewage let out into the open reservoirs;

$\xi_3(1), \ldots, \xi_3(n)$ are sewage contamination characteristics in the urban net;

$\xi_4(1), \ldots, \xi_4(n)$ are sewage contamination characteristics in the object sewerage system;

$\xi_5(1), \ldots, \xi_5(n)$ are sewage contamination control characteristics;

$\xi_6(1), \ldots, \xi_6(n)$ are average proportional concentration characteristic;

$\xi_7(1), \ldots, \xi_7(n)$ are calculated amount of materials during a certain period;

$\xi_8(1), \ldots, \xi_8(n)$ are amounts of materials during a certain period according to the balance of material distribution.

The set of transitions of E-net in Fig. 4.1 is $A = \{u_1,\ u_2,\ u_{2.1},\ u_{2.2},\ u_{2.3},\ u_{2.4},\ u_{2.5},\ u_{2.6},\ u_{3.1.1},\ u_{3.1.2},\ u_{3.2.1},\ u_{3.2.2},\ u_{3.3.1},\ u_{3.3.2},\ u_{3.4},\ u_{3.5.1},\ u_{3.5.2},\ u_4,\ u_5\}$. The examples of the description of transitions:

$a_i = (L'_i[\{\xi_j\}_i],\ L''_i[\{\xi_j\}_i],\ r'_i,\ r''_i, \psi(r'_i, r''_i), q_i, t^p_i, \tau_i, t^f_i, \Pi t_i, st_i)$;

$u_2 = ((D_2[\xi_1, \xi_2], D_5), (b_1, \ldots, b_{1,n}, b_2, \ldots, b_{2,n}),\ r''_2,\ [\psi(r''_2) = r''_2 :\rightarrow M(D_2(\xi_1)) = 0 \rightarrow M(r''_2) := 2;\ (M(D_2(\xi_2)) = 0 \rightarrow M(r''_2) := 1],\ [T \rightarrow M(r''_2) = 1 \rightarrow M(b_1) := M(D_5[\xi_3(1)]), \ldots, M(b_{1,n}) := M(D_5[\xi_3(n)];\ T \rightarrow M(r''_2) = 2 \rightarrow M(b_2) := M(D_5[\xi_4(1)], \ldots, M(b_{2,n}) := M(D_5[\xi_4(n)])]$, the time in which the water amount may be measured, duration of measurements, the time in which measuring is performed, – , st_2);

$u_{2.1} = ((b_1[\xi_3(1)], \ldots, b_{1,n}[\xi_3(n)]),\ ((b_3[\xi_3(1)], \ldots, b_{3,n}[\xi_3(n)]), , , [T \rightarrow M(b_3[\xi_3(1)] := M(b_1[\xi_3(1)]), \ldots, M(b_{3,n}[\xi_3(n)] := M(b_{1,n}[\xi_3(n)]$, the time in which the analysis may be made, duration of the analysis, the time in which the analysis is made, – , $st_{2.1}$);

$u_{3.1.1} = ((b_3[\xi_3(1)], \ldots, b_{3,n}[\xi_3(n)]),\ (b_7[\xi_6(1)], \ldots,\ b_{7,n}[\xi_6(n)],\ b_8[\xi_7(1)], \ldots, b_{8,n}[\xi_7(n)]), , [T \rightarrow M(b_7[\xi_6(1)] := M(b_3[f_1 = (\xi_3(1))]), \ldots, M(b_7[\xi_6(n)]) := M(b_3[f_1(\xi_3(n))], M(b_8[\xi_7(1)]) := M(b_3[f_2(\xi_3(1))]), \ldots, M(b_8[\xi_7(n)] := M(b_3[f_2(\xi_3(n))])$, the time in which the calculation may be caried out, duration of calculations, the time in which calculation is performed, - , $st_{3.1.1}$).

The f_1 is the function of transformation of dynamic characteristics of sewage contamination in average proportional characteristics, f_2 is the function of transformation of dynamic characteristics in the amounts of materials during certain period.

Conclusions. The article considers some essential features of dynamically changing environment in order to create operativelly working DSS. The approach deals with three stages of developing: acquisition, structurization and representation of knowledge for the ecological evaluation system. The problems of data reliability are concerned to ensure the correct and impartial decision making.

The possibility for the E-nets to represent consecutive, recurrent, parallel processes and to model them in time allows to formalize all possible decisions which are determined by concrete conditions at a real time point. Further actions, operations, etc. are specified after the concrete decision have been made. Extending the set of macro transitions, introducing different levels of detailing and using complex procedures of resolution locations it is possible to formalize the behavior of complex processes as well as to represent these processes in the information system and the knowledge base without making the scheme cumbersome. Some temporal parameters introduced in the E-net notation allow to control the net not only automatically but also according to the planned terms and fix the actual moments of transition firing. The abstract concept of specifying temporal relationships between transitions allows to concretely evaluate the event described by the given transition regarding other marked time moments. The extended E-nets are used as formalization means for dynamical representation of behavior of target system and for multicriteria decision making processes.

The knowledge representation framework supports organizational principles in the semantic model of statical aspects.

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Received April 1992

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