A Basis for Evaluation Environmental Pollution Characteristics

Dalė Dzemydienė

Institute of Mathematics and Informatics, Law Academy of Lithuania, Vilnius 2600. Akademijos str. 4. Lithuania
daledz@ktl.mii.lt

Abstract

Environmental protection problems are very important now, and a significance of their solution will rise in near future. This article presents a summary of research activities performed in the field of knowledge representation of rapidly changing and complex environmental protection domain. The consideration is attached to the representation of expertise that could relate the use and analysis of information base and evaluation of circumstances of enterprise functioning that influence the environment pollution characteristics. The knowledge structures simultaneously express mutual object communication and decision-making processes in time. A unified framework is developed through the analysis of various types, aspects, and the role of knowledge relevant to the decision support system using Evaluation nets (the extension of Petri nets). The attention is paid to the representation of dynamic and static aspects of a target system and to the specification of decision-making processes describing general reasoning courses at different levels of detailing.

Keywords: decision support system (DSS), knowledge representation, decision variables, goal structure, E-nets, environment protection.

1. Introduction

The decision support system first of all may secure a possibility of modeling and assessing the situation as well as to enable one to reason defining the presentation of alternative decisions and decision making by choosing one of them.

An ecological situation of a region may be considered as rapidly changing environment. In this subject area we face the problem of representing process development dynamism and rapid information change. In addition, the process poses rather a complex inherent inner structure and mechanisms of interaction between subsystems that are frequently expresses by temporal, geographic, and space dependence conditions.

The problem addressed in this research is that of developing an approach that integrates problem solving and model-based knowledge acquisition within an extensive model of different knowledge types, describing a changing information environment and decision-making processes in a decision support system (DSS). Some exceptional features of the changing environment, especially dynamic components, require additional means for knowledge representation, data verification and assurance of efficiently making decision processes.

In the KADS project [2] an approach to modeling of problem solving expertise has been developed, based on the four layers of expert knowledge:

- the domain layer contains definitional knowledge of the domain;
- the inference layer describes the structure of reasoning and inference mechanisms that operate upon domain layer;
- the task layer explicates knowledge about when a certain inference is to be made;
- the strategic layer sets up the plan for achieving a goal, thereby controlling the reasoning in the task layer.
According to [1] the expertise is knowledge in broadest interpretation of the term and includes factual knowledge of domain, problem solving strategies and methods, and learning strategies. Some components of the expertise model are distinguished in our decision support system as well: the fundamental knowledge that describes the application domain in static (semantic model of information structure) and dynamic (the imitational model of tasks and processes) perspective; the model of the problem solution strategy control level (e.g., plans, diagnostic, strategies of correcting task fulfillment); the reasoning model that embraces stepwise decision support structure.

Rapidly changing environment may include additional techniques for planning, operation control and decision support. A new viewpoint and approaches are needed allowing us to concentrate the attention on the organizational aspects that ensure information for decision support. The technology for building such systems must provide methods for acquisition, structural representation of many types of knowledge taking into consideration the large, shared and distributed databases [3, 10].

Some issues for knowledge representation including the acquisition and structural analysis stages are considered in this paper. The knowledge elicitation process tries to extract knowledge form specialist and experts of application domain. This initially unstructured knowledge is analyzed and structured into an intermediate knowledge model. We propose the Evaluation nets (E-nets) formal means, following [9], which allowed to express the behavioral aspects of events, processes and actions and relate the use and analysis of information structures with the strategy of decision making in time. This model may be viewed as a specification of behavioral aspects of the target system. When modeling problem solution definitely, we combine expertise knowledge and associate it with its purposes and goals in the problem solution process.

2. Decision Making in the Dynamic Environment

One part of a DSS is the model of decision making processes. Referring to a decision support performance analysis the problem is in a representation of goals, plans and in a specification of interaction between the individual steps in decision making and general information environment. The network can ensure the proper application of the information and the reasoning with respect to the knowledge base. A description of a meta-model can include the model of goals, plans and must represent the practice and strategy of reasoning of specialist-experts in making the decision. At the stage of analysis and evaluation of the enterprise performance, the use of this meta-model could allow:

- to recognize what changes in the environment may induce changes in decision goals;
- to decide is the situation relevant for the really application of existing rules or not;
- to specify the process of identification of possible courses of actions and alternatives and to control the choice of concrete variant of these actions by evaluating attractiveness of the consequences of each action.

Decision maker must constantly pay attention to the process because the state of it changes dynamically. Process environments are further characterized by being dynamic, by having multiple and possibly conflicting goals and by having incomplete information. Some characteristics are needed for a great deal of data to properly model and verify these problems [1-2, 10]. We must construct a precise structure of information due to their time and geographical links.

The problems of expression of behavioral aspects of dynamic environmental domain (temporal relationships of process interaction and their determination in time, synchronization of decision making and information processing, communication between the objects, etc.) causes a necessity of designing a conceptual model witch enabled to specify requirements for such type decision support systems [4-8].

Temporal knowledge representation aspects are of primary interest in the decision- making context when the problems of retrospective analysis and prognosis are concerned. In the prognosis
of further evolution of the target area and the system behavior it is important to design the adequate imitation model of the target system functioning. Our consideration of information system aimed at helping in organizational management processes by means of imitation modeling [8,10].

The system for evaluation of enterprises as stationary contamination objects was developed using the theoretical results obtained in [6-7]. In order to evaluate the contamination level of sewage from the enterprise our decision support system analyses the indices of pollution provided in the project, compares monitoring data, inspection data and reports, etc. Decision determines whether to permit a future exploitation or building enterprises and new facilities that pollute or can potentially contaminate surroundings. Decision making is also related with the problem of estimation of the general ecological situation of the given region, the indices of pollution provided in the project, the risk factors related to the preservation of links that are of biological significance and time-dependent, etc.

3. The Possibilities of Evaluation Nets to Specify Functional Requirements

The evaluation nets (i.e., E-nets are the extension of Petri nets) were introduced in [9] and proposed in [4]. The structure and behavioral logic of E-nets give new features in conceptual modeling and imitation of domain processes and decision-making processes. Apart from time evaluation property, E-nets have a much more complex mechanism for description of a behavior of transition work, some types of the basic transition structures, a detailing of various operations with token parameters. In addition to Petri nets, two different types of locations are introduced (peripheral and resolution locations). The exceptional feature is the fact that the E-net transition can represent a sequence of smaller operations with transition parameters connected with the processes. However, a direct application of E-nets to decision making processes requires additional analysis and the modification of their interpretation.

Following [9] it is possible to consider the E-net as a relation on \((E,M_0,\Xi,Q,\Psi)\), where \(E\) is a connected set of locations over a set of permissible transition schemes, \(E\) is denoted by a four-tuple \(E=(L,P,R,A)\), where \(L\) is a set of locations, \(P\) is the set of peripheral locations, \(R\) is a set of resolution locations, \(A\) is a finite, non-empty set of transition declarations; \(M_0\) is an initial marking of a net by tokens; \(\Xi=\{\xi_j\}\) is a set of token parameters; \(Q\) is a set of transition procedures; \(\Psi\) is a set of procedures of resolution locations.

The E-net transition is denoted in [9] as \(a_i=\left(s_i,t(a_i),q_i\right)\), where \(s_i\) is a transition scheme, \(t(a_i)\) is a transition time and \(q_i\) is a transition procedure. In order to represent the dynamic aspects of complex processes and their control in changing environment it is impossible to restrict ourselves on the using only one temporal parameter \(t(a_i)\) which describes the delaying of the activity, i.e. the duration of transition. Therefore, a transition description is extended as follows:

\[
a_i=\left(s_i,t_i^p,\Delta\tau_i,\Pi_i,q_i\right),
\]

where \(i\) is an index of transition; \(s_i\) is a transition scheme and may consist of \((L'_i,L''_i,\psi(r'_i,r''_i))\), where \(L'_i\) is the set of input locations of the transition; \(L''_i\) is a set of output locations of the transition; \(r'_i\) is the location of complex input conditions of a transition (i.e., input resolution location); \(r''_i\) is the resolution location for the transition output; \(\psi(r'_i,r''_i)\) is a procedure of resolution locations. We introduce \(T\) as a time scale and \(t_i\in T\) as time moments denoted on this scale. According to the property of continuity of time, we can define the time interval by starting and terminating moments: \(\tau_i=[t_i,t_j]\), where \(i<j\). The duration of the time interval \(\Delta(\tau_i)\) is defined by a numerical expression of difference \(\Delta(\tau_i)=t_j-t_i\). The periodical time \(\Pi_i\) is defined by a period and base, where the period is defined as duration of an interval, and the base may be either a time moment \(t_i\) or a time interval \(\tau_i\).

The \(t_i^p\) is defined as a planned moment of transition firing, \(t_i^p\in T^*,\) where \(T^*=T\cup\{t_v^*\}\) and \(\{t_v^*\}\) is the set of time moments determined approximately, relatively and etc.
Δτ; is the duration of the transition working time; \Pi; is the periodic transition time. \(q_i\in Q\) is a transition procedure, which according to the rules of transition maps \(M\times L'\times \Xi'\) into \(M\times L''\times \Xi''\) and determines the flow of tokens \(m\in M\) with parameters \(\{\xi_j\}\) from input locations \(\{b'_j\}\) into output locations taking account the results of procedure \(\psi(\ r'_i, r''_i)\) at the actual time moment \(t'_i\), where \(\Xi', \Xi'' \subset \Xi\).

A concrete parameter of token obtain a concrete value according to its identification, when the token is introduced into the location \(b_j(\xi_k)\). Such a combination of locations with the tokens in them, the parameters of which obtain concrete values, describes a situation for process execution.

Such an understanding of the transition procedure enables us to introduce the time aspects into procedure of control of processes and determine operations with token parameters in time dimension. The exceptional feature is the fact that the E-net transition can represent a sequence of smaller operations with transition parameters connected with the event/process. Operations are described in the transition procedure with these parameters.

![Figure 1. The E-net transition schema](image)

The E-nets support a top down design in graphical representation manner. The hierarchical construction of dynamic model is simplified by representing macro-transition and macro-location constructions. The input locations \(L'_i\) of the transition correspond to the pre-conditions of the activity (represented by the transition in Fig. 1). The output locations \(L''_i\) correspond to post-conditions of the activity. The complex rules of transition firing are specified in the procedures of resolution locations \(\Psi\) and express the rules of process determination.

### 4. Description of Decision-making Circumstances

We consider a decision making process by analyzing a space of possible problem solutions. Every decision is a result of a dynamic process influenced by many factors. Decision processes may be structured by a certain number of typical processes that reflect different phases of problem analysis, diagnostics, estimation, choice of the object priority, resource planning, decision realization, etc. In each of these stages we identify and define a problem, analyze alternative decision versions. Having estimated all the conditions and risk factors, an optimal decision is selected that is realized.

To express the structure of a decision making process, the basic sequences of functional reasoning are joined with information processes. As a result the 'states of knowledge' are obtained. Such states are involved into the process of decision-making. This analysis is significant for
identifying the strategies of information processing which are efficient at different phases of the sequences of decision-making steps.

In order to identify necessary data, control structures, and information processing possibilities, we have to imitate cognitive tasks. In each case, it is of importance to find criteria such that would make it possible to choose more useful and reliable decisions out of possible alternatives.

We have distinguished three levels of knowledge representation in the system: the semantic data model of static aspects of the target system, the model of behavioral analysis of activities in target system, and a model of decision making processes (Figure 2.). The main attention is paid to the representation of dynamic aspects of the application domain and to the specification of decision-making processes. The decision support is represented as inference engine of different levels of reasoning courses that combine the analysis of a model of dynamic changes in the domain.

The model of behavioral analysis of the target system shows the dynamics of observable processes. The adequate imitation model of the behavioral analysis allows to predict further evolution of the target system and to increase the quality of decision-making.

The multiple objective decision making deals with the analysis of information obtained from the static sub-model taking into account all possible measurement points revealed in dynamic sub-model of such a system (Figure 2.).

The task structure relationship with information elements, the course of decision-making processes and presentation of alternative variants of decisions are represented in this sub-model. The modeled system is regarded as direct mapping of the real enterprise system, and decisions can be based on decisive facts and followed rather deterministic rules.

4.1 Interpretation of Decision Making Processes by E-nets

The rules in a given system are interpreted by the set of transitions $A=\{a_1, a_2, \ldots, a_n\}$ of the E-net. The locations $L=\{b_1, b_2, \ldots, b_m\}$ are corresponded to conditions (facts), so that the condition of applicability of each rule consists of simultaneous accomplishment of a certain totality of conditions $\{b_{i1}, \ldots, b_{in}\}$. Using means of E-nets the representation of decision-making processes are very similar to the form of a production rule system, where production rules are of the form: 

$IF <\text{conditions/premise/situation}> THEN <\text{conclusions/situation}>$. 
Each condition from the given totality may be a compound vector, i.e., may consist of the set of elementary conditions:

\[ b_k = \{ b_{ik}(\xi_1), b_{ik}(\xi_2), \ldots, b_{ik}(\xi_m) \} \]

Rule applicability is determined by the truth or falsity of various combinations of elementary conditions. The condition

\[ M(b_{ik}) = 1 \]

means that the token is in the location \( b_{ik} \) and is confirmation of this condition.

The transition having a resolution location allows the situation to be described by using various combinations of conjunctions and disjunctions among such conditions:

\[ M(b_{ik}). \]

The result of a rule may be either the combination of conditions making another rule, or a final inference. The purpose of the analysis of the rule system is finding the sequence of the rules implying the fact we are interested in. The net allows representation of various procedures forming sequences of rules that may include consecutive, recurrent, parallel or mixed inferences. The whole inference process may be described as the evolution of the dynamic system. The terminal or objective set of states are interpreted by set of output (terminal) locations \( \{ p''_j \} \). The purpose of inference will be achieved if condition:

\[ M(p''_j) = \prod M(p''_j) = 1 \]

where \( \{ \xi_m \} \) are the token parameters in the location \( p''_j \).

The complexity of the decision making task consists in finding the best decision under multiple criteria. As the number of alternatives increases, multi-criteria evaluation involves a mechanism for rejecting a number of those alternatives. By analyzing the possible choice mechanisms (under lack of information about the importance of criteria, or assuming the criteria are equivalent), the acceptable decision variant seems to be not so easily chosen. It is expedient to make a choice according to a weighed criterion. Then the basis for choosing the decision variant is qualitative information on the relative importance of each separate criterion.

It is possible to determine the set of final inferences \( \{ p''_j \} = P'' \subset P \) as a discrete set of decisions or alternatives (variants) available for choice. In the real choice tasks, the variant are not in arbitrary order: some variants may exclude others, while others are always accompanied. The set of criteria functions is denoted as \( G = \{ g_1, g_2, \ldots, g_n \} \). The function \( f \) allows depiction of the variant \( g_k (p''_j) \) according to the criterion \( g_k \) is designated by \( p''_j (\xi_k) \). We call the collection

\[ p''_j = (p''_j(\xi_1), p''_j(\xi_2), \ldots, p''_j(\xi_m)) \]

the vector estimation of the variant \( p''_j \).

Choice according to the weighted criterion \( g_k, k = 1, \ldots, d \), is based on the weight \( w_j \geq 0 \) which estimates characterizing relative importance of the criterion. The choice function:

\[ C_w (P'') = \{ p''_i \in P'' \mid (\forall p''_j \in P'')( (\hat{w} \cdot p''_i) \geq (\hat{w} \cdot p''_j)) \} \]

is determined by weighted sum:

\[ \sum_{i \leq k \leq d} \hat{w}_k p''_j(\xi_k) = (\hat{w} \cdot p''_j), \text{ where } \hat{w} = (w_1, \ldots, w_d). \]

The goals are means for orienting the organization activities towards desired results. In the general process of creating an information control system, the stage of goal formulation is one of the main stages that affect both the general organization structure and decisions. In addition, the process poses rather a complex inherent inner structure and mechanisms of interaction between subsystems that are frequently expresses by temporal, geographic, and space dependence conditions.
5. The Model of Goal Structure of Water Pollution Evaluation

The existence of goals is one of the main characteristics of an organization. The goals (aims, objectives) form motivation factors in order that the tasks (problems) of the organization can be accomplished. The model of goal structure of the organization (e.g. enterprise) can be expressed by an asymmetric graph that has no cycles:

\[ S=(G,R) \]

Where \( G=\{G_i\} \) is the \( k \)-th goal (aim, wish, objective), \( k =1, \ldots, K \).

\( R \) is the set of all the relations between goals; its elements are: \( R=\{r_{kl}\} r_{kl}=(G_k, G_l) \).

Each relation \( r_{kl}=(G_k, G_l), k =1, \ldots, K \) reflects a direct contribution of the goal \( G_k \) to \( G_l \).

On the strategic control level plans and meta-rules are formulated, functioning interference of the system identified, and the failure probability is established. These control objects determine object structures and tasks on the level of task formulation. On the level of reasoning derivation these structures apply knowledge sources, meta-classes, and formulate derivation structures.

Descriptions of subject area concepts, relations and their structures as well as the axiom system are used on the level of derivation.

In order to make a decision on estimating several criteria whose values can be formally calculate for any plan (object), one has to estimate it quantitatively. If there is a single goal \( G_1 \), then the actual value of ‘action – result’ is equal to the contribution into the desirable value:

\[ v_{ij} = G^{ij}, \text{ where } i = 1, \ldots, m, \quad j = 1, \ldots, n \quad (5.1) \]

Let the goals (i.e., aims, wishes) of a decision maker correspond to a set \( GD \):

\[ GD= \{G_{d1}, G_{d2}, \ldots, G_{dD}\} \quad (5.2) \]

The significance of the pair ‘action-result’ is measured by the decision maker by the contribution to the concrete goal of the set \( GD \). If there is any way to estimate the contribution of ‘action-result’ to the goal, then one can estimate the unique ‘action-result’ value as the sum of their contributions weighted according to priority factors \( \{q_{dk}(t)\} \):

\[ v_{ij}(t) = q_{d1}(t) G^{ij}_{d1} + q_{d2}(t) G^{ij}_{d2} + \ldots + q_{dD}(t) G^{ij}_{dD}, \text{ where } i = 1, \ldots, m, \quad j = 1, \ldots, n \quad (5.3) \]

Here \( q_{dt}(t) \) is the goal priority factor established by the decision maker that describes a relative importance of the goal \( G^{ij}_{dt} \) at a certain time moment \( t \). The relative importance of the goal is compared with other objects in the set \( GD \).

The goal of the manufacture enterprises is to rationally develop an ecologically clean production. It means that enterprises (e.g. factories, plants, etc.) must guarantee the manufacture of products with minimal pollution of the environment and damage to nature, not exceeding the permissible standards.

Thus we have a problem of two objectives/goals:

\( G_1 \) – increase in capacity of production and profits of the enterprise under consideration;

\( G_2 \) – decrease in environmental pollution within the permissible limits.

The first criterion \( \hat{N} \) – the profit of production has to be maximized while the second criterion \( \hat{O} \) – the environmental pollution has to be minimized. The importance of the first criterion is determined by various economic industrial parameters. The maximization of its importance is of direct interest to and care of the producers. The main task of our decision support system is to maintain the importance of the second criterion \( \hat{O} \) within the permissible limits and thus act on the
first criterion. The $\tilde{O}$ criterion is stipulated by three factors: water pollution, air pollution and contamination of harmful solid wastes: $\tilde{O} = \{W, A, H\}$.

More in details we consider the example of the analysis of water resources and the pollution of sewage of the enterprise. The pollutants from the production are entering into the water in some types of cases. Such cases we find out by the construction of E-net distribution processes of sewage in the enterprise (Fig. 3).

![E-net diagram](image)

Figure 3. The E-net of distribution processes of harmful materials in the water of an enterprise

The tasks and sub-processes are shown as transitions, while inputs/outputs from the processes are shown as positions of E-net.

The initial task is always data gathering, resulting in a set of observed findings.

The materials are classified by the rate of their harmfulness. Such materials (which are ecologically dangerous) are the main decision variables of the sewage analysis task:

$H_1$ – are pollutants of first rate of harmfulness into water bodies, which are especially dangerous;
$H_2$ – are pollutants of second rate of harmfulness;  
$H_3$ – are pollutants of third rate of harmfulness;  
$H_4$ – are pollutants of unidentified effect. 

The highest permissible contents or interim permissible concentrations of these substances in water are established dependent on the type of the water reservoir the polluted sewage eventually gets into.

The harmful materials that are represented by peripheral locations of the E-net (in Fig. 3) are very important for evaluation of water pollution of an enterprise: 

$p_{1,1}, \ldots, p_{1,n}$ are materials included in water efflux;  
$p_{2,1}, \ldots, p_{2,n}$ are waste materials from the primary sewage purification plant;  
$p_{3,1}, \ldots, p_{3,n}$ are waste materials from the common sewage purification plant;  
$p_{4,1}, \ldots, p_{4,n}$ are materials entering into open reservoirs, that are not detained in the sewerage system of the enterprise;  
$p_{5,1}, \ldots, p_{5,n}$ are materials entering into open reservoirs, if there is no rainwater collection system;  
$p_{6,1}, \ldots, p_{6,n}$ are utilized wastes from primary purification plants;  
$p_{7,1}, \ldots, p_{7,n}$ are materials entering into rain water if they are stored openly in the territory of enterprise;  
$p_{8,1}, \ldots, p_{8,n}$ are materials entering into the external reservoir from the primary sewage purification plant.

The E-net structure, which describes the decision-making process, gives visually the parameters needed for control and the control structure relation with tasks and decisions.

The highest permissible contents or interim permissible concentrations of these substances in water are established dependent on the type of water reservoir the polluted sewage gets into. The example of conceptual structure of data of norms of greatest permissible concentrations of materials is presented in Fig. 4.

6. The Representation of Expertise Structure

The main steps of diagnosis are suggesting a fault and undesirable performance of functioning enterprise on the basis of the problem description. Such task is highly complex, since solving a problem often involves iterative loops, backtracks, shortcuts, etc.
A large amount of measurement points at different time and conditions causing overlapping and conflict between different observations, and the inaccuracy of measurements and reports.

Another essential aspect of such application domain is their spatial dimension. While in many other application domains the problems study are within very precise and, usually, narrow framework, for instance a plant, factory or firm contamination problem deals with spatially and temporally varying phenomena with very unbounded limits.

The multiple objective decision support level deals with the analysis of information obtained from the all measurement points revealed in the dynamic sub-model of DSS. The modeled system is regarded as direct mapping of real enterprise system and decisions can be based on decisive facts and follows rather deterministic rules.

Decision support is also related with the problems of estimation of general ecological situation of the given region, the indices of pollution provided in the project, the risk factors related to preservation of links that are of biological significance and time dependent, etc.

![Figure 5. The E-net of evaluation making for water diagnosis task](image)

The expertise may include the following aspects of analysis: usage of materials and natural resources in the production process; emission of harmful materials into the air and into territorial waters and soil; utilization of waste materials from the production process; usage of purification equipment. The structure of determination of systematic rules for analyzing sewage contamination is represented by the E-net in Fig. 5.

The information needed for such evaluation are represented in positions:

- \( p_{v1} \) is outlet amount of sewage released into urban net;
- \( p_{v2} \) is outlet amount of sewage released into open reservoir;
- \( p_{dt} \) is amount of working days;
\( p_d \) is time period with respect of accounting is done;
\( b_{1,1} - b_{1,n} \) are materials detected in purification plant of enterprise;
\( b_{v2,1} - b_{v2,n} \) are amounts of harmful materials accumulated in purification equipments;
\( b_{v3} \) is amount of sewage released into urban net per day;
\( b_{v4} \) is the amount of sewage released into open reservoir per day;
\( b_{v5} \) is the type of sewage
\( b_{v6} \) is the established character of analysis;
\( b_{v7} \) is a frequency of analysis;
\( b_{v7} \) is the co-ordinates of inspection of sewage according to the water receiver;
\( b_{m,1} - b_{m,n} \) are materials which may estimate;
\( b_{c,1} - b_{c,n} \) are results of determination of sewage contamination according to greatest permissible concentration norms for separate type of receivers;
\( p_{d,1} - p_{d,n} \) are norms of contamination of the harmful materials (HM).

<table>
<thead>
<tr>
<th>Character of sewage analysis</th>
<th>Frequency of sewage analysis</th>
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<tbody>
<tr>
<td>Outlet amount of sewage</td>
<td></td>
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<tr>
<td>Released into urban net [m³/day]</td>
<td>Released into open reservoir [m³/day]</td>
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<tr>
<td>From industrial processes</td>
<td></td>
</tr>
<tr>
<td>( b_{v3} &gt; 500 )</td>
<td>Common analysis and determination of specific obligatory materials</td>
</tr>
<tr>
<td>00 ≤ ( b_{v3} ) ≤ 500</td>
<td>Common analysis and determination of specific obligatory materials</td>
</tr>
<tr>
<td>( b_{v3} &lt; 100 )</td>
<td>Analysis not carried out</td>
</tr>
<tr>
<td>( b_{v4} ≥ 100 )</td>
<td>Extended analysis</td>
</tr>
<tr>
<td>( b_{v4} ≤ 100 )</td>
<td>Extended analysis</td>
</tr>
<tr>
<td>From consumer services</td>
<td></td>
</tr>
<tr>
<td>( b_{v3} &gt; 500 )</td>
<td>Dynamic characteristic of separate specific materials</td>
</tr>
<tr>
<td>100 ≤ ( b_{v3} ) ≤ 500</td>
<td>Dynamic characteristic of separate specific materials</td>
</tr>
<tr>
<td>( b_{v3} &lt; 100 )</td>
<td>Average contamination characteristic</td>
</tr>
<tr>
<td>( b_{v4} ≥ 100 )</td>
<td>Dynamic characteristic of separate specific materials</td>
</tr>
<tr>
<td>( b_{v4} ≤ 100 )</td>
<td>Extended analysis</td>
</tr>
</tbody>
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The rule \( r_3 \) is applied in E-net for \( a_{2,3} \) transition description is specified as in Table 1. Rain and mixed water is treated as sewage from industrial processes.

In conformity with the values of analysis variables and exceeding permissible standards the decision support system has to make one of these following decisions:

1. To permit the functioning of enterprise and give the permission in which the drinking water amount to be used during certain time period is determined as well as the amounts and characteristic of sewage into appropriate water collection system or water reservoir;
2. To impose a fine on a enterprise for environmental pollution within certain range;
3. To restrict the functioning of an enterprise production processes.
7. Conclusions

Dynamic environment have a significant dynamic component, which means that the conditions of the real system at the time the decision is made, are the results of all the past history of the system and influence its subsequent behaviors. Some issues for a qualitative knowledge representation including the acquisition and representation stages are considered.

The approach of applying E-net formal means to conceptual modeling of dynamic aspects of the domain and to specifying decision making allowed to express the behavioral aspects of processes in a hierarchical construction and leveling manner without making complicated schemes. The functional requirements specification interrelated with the use and analysis of information structures and the strategy of decision-making processes. The decision making sub-model represents all reasoning courses at different levels of detailing. The decision support generates the alternative variants of decisions at actual conditions. The inference engine (represented by using E-nets) applies the knowledge to the solution of an actual problem and it acts as a control system.

8. References


