WEB-BASED INFORMATION SYSTEM FOR THE IMPACT ASSESSMENT OF ENERGY ON THE GEOECOLOGY OF THE REGION

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***Abstract**: This article formulates and briefly discusses the formulation and proposed approaches to solving the problem of the impact of energy on the geoecology of the region. Applied semantic technologies are also presented, for example, such as ontological and cognitive. The main attention is paid to the Web-oriented information system - its structure, main components and approaches to implementation, as well as one of the most important components of the system –Contingency Management Language CML.*

1. Introduction

This work is being executed as a part of international project, which is supported by EAPS and RFBR, for research of impact assessment of energy on region geoecology. Aim of the project is to develop methods and technologies for assessing the impact of energy on region geoecology. Geoecology is understood as interdisciplinary scientific direction, which combines research of composition, processes, physical and geochemical fields of the Earth’s geospheres as habitats of humans and other species [2]. Main task of geoecology is to study the changes in the life-supporting resources of the geosphere shells under the influence of natural and anthropogenic factors, their protection, rational use and control with the purpose of preserving for the present and future generations of people a productive natural environment. More details description of geoecology, quality of life, as well as proposed approaches and methods are discussed in the article by Massel L.V. "Intelligent decision-making support in energy and ecology in view of the quality of life".

For development of tools for intelligent decision-making support in areas of energy and ecology, project uses methods of geoinformation technologies based on 3D-geovisualization [3], methods for critical infrastructures research [4], methods for decision-making support, methods for knowledge engineering, methods of object approach and also authors’ methods of situational management, semantic modelling and intelligent tools for its support. For this project it is proposed to develop and adopt authors’ methods of creating ontological space, knowledge in area of energy; methods of semantic modelling in energy, 3D-geovisualization methods and methods of visual analytics with elements of cognitive graphics, and also methods for development intelligent systems for support strategic decision-making in energy [4]. Also, authors will use experience gained by Russian and international scientists [5, 6, 7, 8].

This article deals with Web-oriented information system (WIS) - which integrates mathematical and semantic methods and tools for impact assessment of energy on geoecology of region, database, knowledge base and geoinformation system. It is supposed to use the results of the authors of the project, carried out earlier to study the problems of energy security: tools for semantic modeling, Geocomponent, tools for working with the knowledge base and the Repository.

2. Semantic technologies

In general, semantic modelling is understood as information modelling, based on extraction of main terms (concepts) of subject area and connections between them. Thus, semantic models can be classified as ontologies, as well as semantic networks and infologic ER-models [4]. Since 2013, in articles of L.V. Massel it is shown that cognitive, event and probabilistic (based on Bayesian network) modelling can be referred as semantic technologies. Methods and tools of this modelling are actively developed by the team, represented by the authors [4].

2.1 Ontological modelling

According to Guarino, ontological modelling is understood as “specification of conceptualization” or identification of the basic terms (concepts) of the domain and links between them and their description. Ontological modelling was discussed more detailed in articles of T. Gruber [9], N. Guarino [10-11] and others, as for Russia – in articles of T.A. Gavrilova, Yu. A. Zagorulko, L.A. Kalinichenko, Kogalovsky M.R., Serebryakov V.A. and others. Works performed under the leadership of Massel L.V. in this area were presented, in particular, at the ZONT conference, which is held in Novosibirsk.

2.2. Cognitive modelling

Cognitive modelling is understood as cognitive models creating, or, in other words, cognitive maps (directed graphs) in which vertices are corresponding to factors (concepts) and edges are connections between factors (positive or negative) depending on the nature of the cause-effect relationship. The mathematical apparatus for constructing cognitive models is the graph theory. The fundamentals of cognitive modeling were developed in due time by Wang Hao (1956), R. Axelrod (1976), D. A. Pospelov (1981).

This scientific direction was developed in the works of E.A. Trakhtengerts, at present it is actively developing in the V.A. Trapeznikov Institute of Control Sciences of the Russian Academy of Sciences (Abramova N.A, Kulba V.V., Kulinich A.A., Maksimov V.I.) for the analysis of influences in managing weakly structured situations.

2.3. Event modelling

By event modelling is understood the construction of behavioural models and as objects of modelling can be considered both people and technical objects. The task of the event modelling method is to track the sequence of events on the model in the same order as they would occur in the real system. As an event modelling tool, the Joiner-Network (JN) is used - one of the varieties of algebraic networks proposed by L.N. Stolyarov [12]. The peculiarity of JN is that it provides both a graphical representation and description in the form of logical formulas, the processing of which can be automated. Works performed under the leadership of Massel L.V. in the field of cognitive and event modelling, are reflected, in particular, in [4].

2.4. Probabilistic modelling based on Bayesian network

Bayesian networks of trust are graphical models of probabilistic and cause-effect relationships in a set of variables that are described by a directed acyclic graph whose vertices are variables and the edges show conditional dependencies between them. The basis of this tool is the Bayes theorem. Fundamentals of the tool of graphical probability models (in particular, Bayesian networks) were developed by J. Perl, R.J. Cowell, and others. In Russia this apparatus was considered by V.I. Gorodetsky, A.L. Tulupyev, and others. Works done under the leadership of Massel L.V, are described, in particular, in [13].

3. Web-oriented information system

As it was said in the introduction, it is planned to create a Web-oriented information system (WIS) for the project implementation. Fig. 1 shows the architecture of this system.

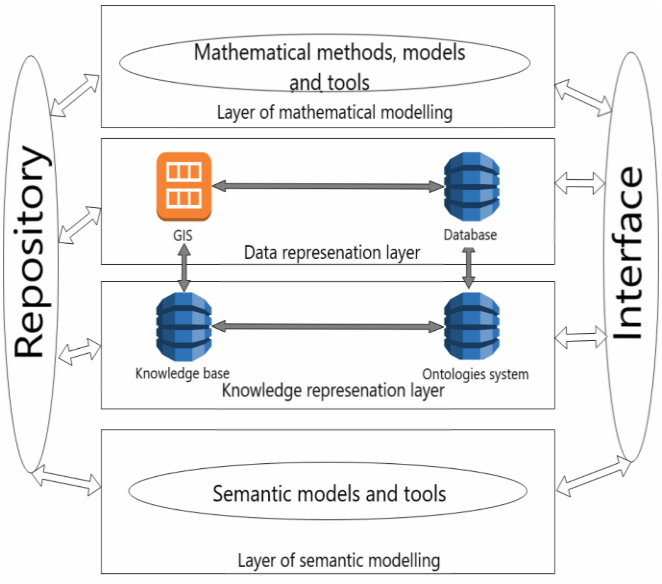

***Fig. 1** Architecture of Web-oriented information system*

This system will be based on the integration of the geo-information system, mathematical and semantic modelling tools, tools for assessing the impact of energy on the geoecology of the region, databases and knowledge base. Some components of the system will be implemented using multi-agent technology.

As it seen from the architecture mentioned above, system will consists of four layers:

- **Layer of mathematical modelling** - contains programs, developed on the basis of selected methods and models, for calculating the amount of pollutants and their impact on the quality of life of the population, taking into account the capacity of energy facilities (energy supply) and population (population density) in the considered territory.
- **Data representation layer** - integrates geoinformation system (GIS) and database, including geographic coordinates of energy facilities. GIS can be used both to illustrate the results of calculations, and for visual interpretation of semantic models
- **Knowledge representation layer** – contains a knowledge base that stores descriptions of knowledge for constructing semantic models, and an ontology system for describing knowledge of the subject domain; the latter can be used both for building a knowledge base and for designing a database.
- **Layer of semantic modelling** – contains semantic models for describing the interconnection of factors that determine the quality of life, taking into account anthropotechnical factors: energy supply and the impact of pollutants from energy companies on the environment

The metadescriptions of the information which is presented on all four levels are stored in the Repository. When implementing the user interface, it is supposed to apply the situational calculus [15] and the components of the Contingency Management Language CML, which is one of the most important components of the WIS and will be considered in the next section.

4. Contingency Management Language CML

One of the basic components of WIS is the CML – Contingency Management Language. Fig. 2 represents its metaontology.

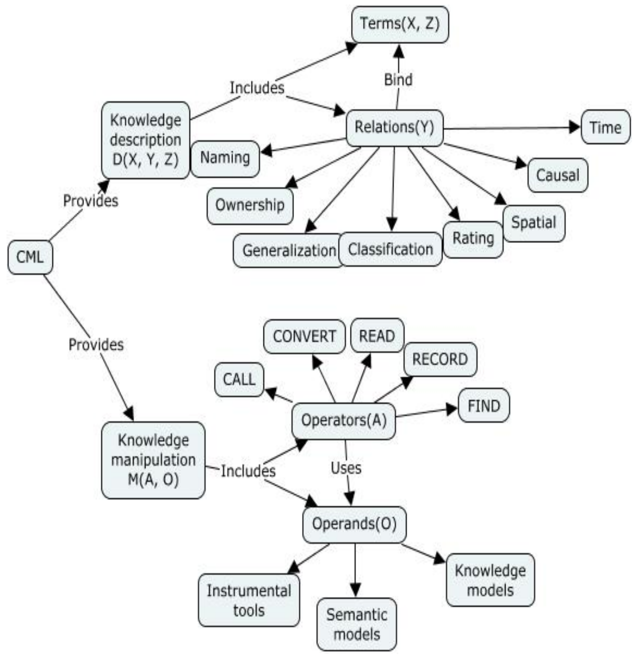

***Fig. 1.** Metaontology of Contingency Management Language*

It includes two parts: (D, M): (1) tools for knowledge description D (descriptions of situations, scenarios and actions) and (2) tools for knowledge manipulation M (call of tools and usage of both semantic and knowledge models).

This language will be based on the integration of situational management and situation calculus. The possibility of such integration was considered by the authors in [16]. Now let's consider how, with the help of this integration, it is possible to describe some of the concepts of the situation description component.

- **Relations of naming:**
  <object> <has> <name>
  <object> := <physical object> | *<software component>* | *<informational component>*
  For this type of relations it's possible to use object characteristics, introduced in situation calculus.
- **Relations of classification:**
  <situation> <has type> <initial | *transitional* | *target>*
  <control action | *measure> <has type> <preventive* | *operative* | *liquidation>*
  Situation calculus aims to classify situations and actions. To classify threats it makes sense to use the dictionary of names and terms.
- **Spatial relations:**
  <situation> <happens at> <location>
  to describe these relations it is proposed to use the dictionary of names and terms.
- **Time relations**:
  <situation> <happens at> <time>
  When describing these relations one might stick to the concept of time, because in the situation calculus it sets the onset time of specific situation.

Tentative analysis shows that in such a way it is possible to consider all proposed relationships and to compare them with the basic concepts of situational calculus.

For the program implementation of this language, it is suggested to use the program complex Semp-TAO, developed at the A.P. Ershov Institute of Informatics Systems of the SB RAS. At the core of the complex is a knowledge representation model that combines classical and modern tools of representation and processing of knowledge: frames, production systems, semantic networks [17]. The main tool of representing declarative knowledge is the semantic network. Processes of information processing and output are specified in the form of a system of products that work on a semantic network.

Based on this model, the language of representation and processing of knowledge was developed, which is intended for specification of applications in various subject areas and has a rich set of tools for this purpose [18]. The language allows to represent the concepts of the domain in the form of classes of objects and relationships, create new data types and specify the required output and data processing processes in applications, and includes tools necessary for creating user interfaces and working with text files. Next, an example of an ontology will show how, with the help of this complex, it is possible to describe an ontology.

First, we'll create the following base classes: **commonObject** – describes common object in system. It has next fields "name" (object name), "*global_id*" (object id in database), "*owner_id*" (model's identifier to which object belongs) и "*inner_id*" (object id inside model).

commonRelationStruct – describes common relation between objects. It has following fields "*global_incoming_id*" (global identifier of the object from which the connection is made), "*inner_incoming_id*" (inner identifier of the object from which the connection is made), "*global_outer_id*" (global identifier of the object to which the link is connected), "*inner_outer_id*" (inner identifier of the object to which the link is connected) и "*value*" (value of this relation).

commonMap - describes common model object. It has following fields: "*global_id*" (model's id in database), "*name*" (model's name) и "*description*" (model's description).

Now, consider how one can use the classes above to describe ontology. Preliminarily, we'll create class, which describes ontology concept with following fields: "*incoming_relations*" (set of object incoming relations) and "*outgoing_relations*" (set of outgoing relations). This class is inherited from *commonObject* class. Then, ontology class is described, it consists from single field "*objects*", which is a set of ontology concepts. Also, this class extends *commonMap* class.

Thus, it can be seen that using the Semp-TAO language it is possible to describe the concepts of the contingency management language included in the knowledge description component.

5. Results and discussion

The article proposes an approach to solving the problem of monitoring the impact of energy on the geoecology of the region, based on the integration of mathematical models, GIS technologies and modern intelligent technologies in the framework of a Web-based information system (WIS). The proposed WIS is a prototype of the intelligent decision-making support system for improving the quality of life, taking into account the requirements of geoecology, including an improved analytical tool for estimating emissions of energy objects and the spread of pollution.

Conclusion

- The applied technologies of semantic modelling are briefly described.
- The architecture of the Web-based information system is presented and the components of this system are described.
- One of the most important components is considered – Contingency Management Language CML and approaches to its implementation, based on the integration of concepts of situational management and situation calculus using the software package Semp-TAO, was shown.

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