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Knowledge management language in the information and analytical system for impact assessment of the energy on the geoecology

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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. A brief description of the applied semantic technologies, such as ontological, cognitive, event-based and probabilistic, is given. Main attention is paid to a Web-based information and analytical system. The article shows the architecture of this system, provides a description of the main agents of the system and a description of the main components, including the Knowledge Manipulation Language (KML). KML structure is considered, detailed description of this language and its components are presented and some examples of KML components is shown.**

Keywords*— *geoecology, information system, knowledge management language, impact assessment.

I. INTRODUCTION

This work is carried out as a part of international project, supported by the RFBR and EAPS funds, for research of impact assessment of energy on region's geoecology [1]. Aim of the project is development of 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 problem of the geoecology is 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.

In order to develop tools for intelligent decision-making support in areas of energy sector and ecology, project utilizes methods of geoinformation technologies based on 3D-geovisualization, critical infrastructure research methods, decision-making support methods, knowledge engineering methods, methods of object approach, and also authors' methods of situational management, semantic modelling and intelligent tools for its support. Also, development and adaptation is proposed for authors' methods for: creation of ontological knowledge space in area of energy sector; semantic modelling in energy sector, 3D-geovisualization and methods of visual analytics with elements of cognitive graphics, and also methods for development intelligent systems for support strategic decision-making in energy sector. Authors will also use experience gained by Russian and international scientists [3-6].

This article deals with Web-oriented information and analytical system (WIS) for energy impact assessment on region's geoecology. This system is being developed as a part of the project, mentioned above. WIS integrates both mathematical and semantical methods, tools for energy impact assessment, 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 modelling, Geocomponent, tools for working with the knowledge base and the Repository

II. 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 [7].

This project utilizes following semantic technologies:

- ***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 [8], N. Guarino [9,10] and others.
- ***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 R. Axelrod [11], D. A. Pospelov [12].
- ***Event modelling*** - event modelling is understood the construction of behavioral 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 [13].

- ***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 (Bayesian networks) were developed by J. Pearl [14,15], R.J. Cowell [16] and others.

Since 2013, in articles of L.V. Massel it is shown that mentioned modellings can be referred as semantic technologies. Methods and tools of this modelling are actively developed by the team, represented by the authors [7].

III. Web-oriented Information and Analytic System

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

This system is based on integration of geoinformation system, mathematical and semantical modelling tools, tools for impact assessment of the energy sector on region's geoecology, databases and knowledgebase. Some of the system's components will be implemented using multiagent technology [17,18].

According to the architecture, displayed in fig. 1, system is divided in four layers:

- ***Layer of semantic modelling*** – contains semantic models for descriptions of factors connections, that determine the quality of life, considering anthropotechnical factors such as: impact of pollutants from energy companies on the environment and energy supply.

- ***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.

- ***Knowledge representation layer*** – contains knowledge base, that stores knowledge description 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.

- ***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.

Considering usage of multiagent technology for implementation of some components, it will include following "large" agents:

- ***Main agent-coordinator*** – monitors the actions of coordinating agents, contains agent scenarios, based on which builds the order of calling coordinating agents, also controls the actions of the user in the system

- ***Database agent-coordinator*** - provides access to the system database

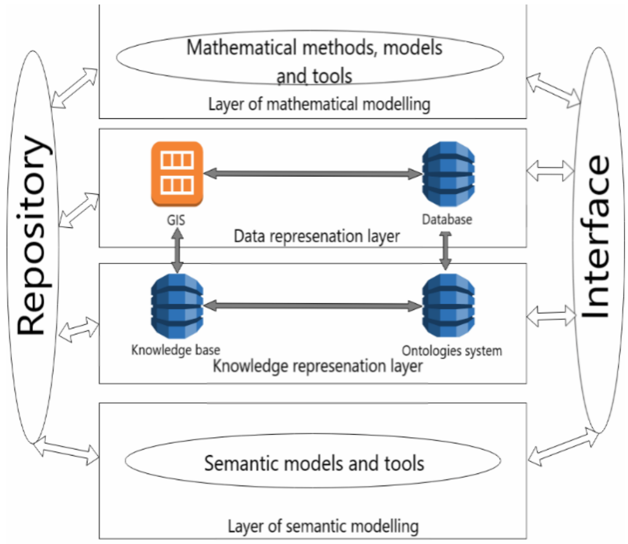

Fig. 1. Architecture of Web-oriented information system

- ***Knowledge base and Repository agent-coordinator*** - provides access to the system database and Repository

- ***Agent-coordinators of semantic and mathematical modelling tools*** – control agents responsible for certain modeling tools. Also, each tool is also an agent.

- ***Agent coordinator of visualization and Geocomponent*** – provides the ability to visualize the obtained results, for example, in the form of ontologies, cognitive maps, or with the help of map services.

Metadescriptions of 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 [19] and the components of the Knowledge Manipulation Language (KML), which is one of the most important components of the WIS and will be considered in the next section.

IV. Knowledge Manipulation Language

As it was said in the introduction, Knowledge Manipulation Language (KML) is the one of the main components of WIS. Currently, this language is under development by the team, that authors represent. It is proposed to use KML for:

- Knowledge description and knowledge manipulation
- Interaction with the Repository
- Tool for invoking the corresponding tools of semantic and mathematical modelling
- Tool for invoking geocomponent (GIS) for 3D-geovisulization

KML includes two parts (D, M): tools for knowledge description D (describes situation, scenarios, control actions) and tools for knowledge manipulation M (invoke of tools and usage of both semantic and knowledge models, GIS invokation).

Fig.2 represents metaontology of KML

A. Knowledge description

Section, responsible for knowledge description, includes dictionaries of concepts and relations. For knowledge description simple atomic construction (XYZ) is used, where X, Z — concepts or names, Y — relation or action. As for now, KML includes following relations:

- Naming
- Ownership
- Generalization
- Classification
- Rating
- Spatial
- Causal
- Time

For implementation of relations, it is proposed to some concepts of situation calculus [20]. Fig.3 shows metaontology of situation calculus.

Now, we'll consider some of the relations of KML, related to the knowledge description component, and compare them with the concepts of the language of situation calculus with the help of which they can be expressed:

- ***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.

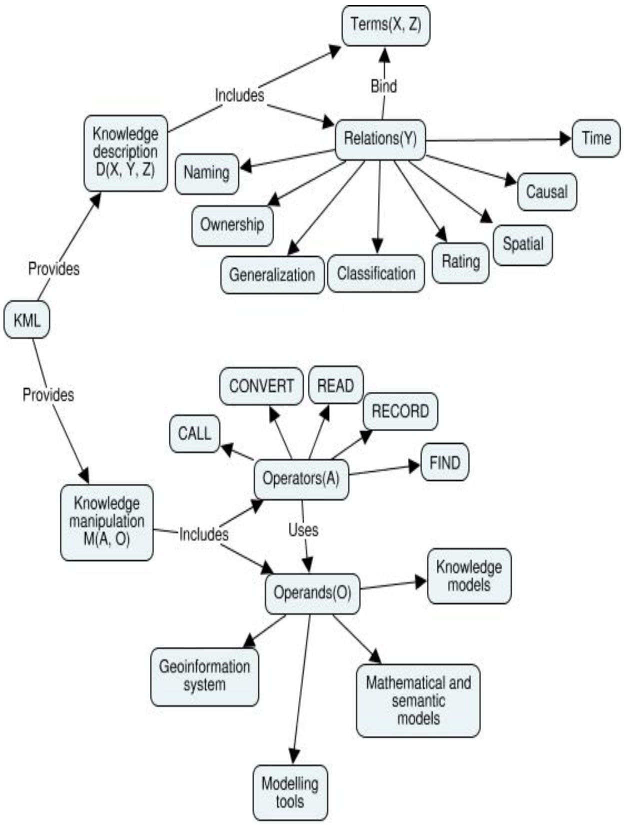

Fig. 2. Metaontology of Knowledge Manipulation Language

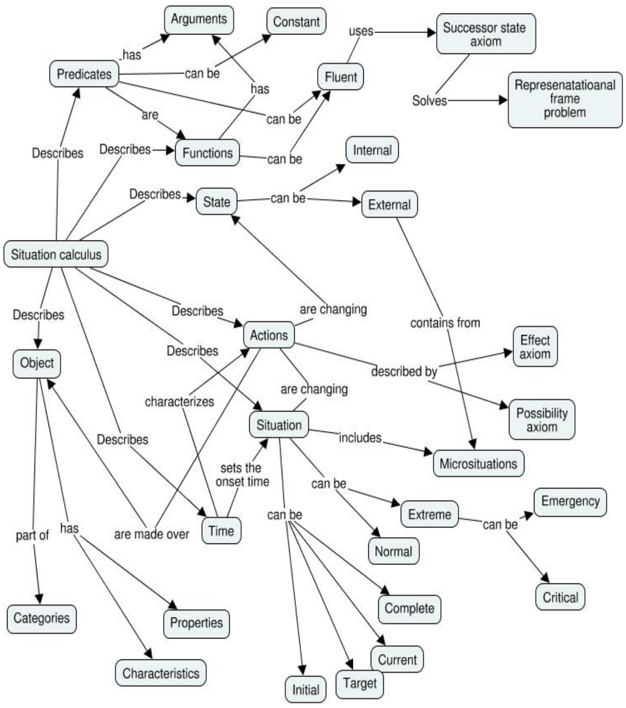

Fig. 3. Metaontology of situation calculus

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. Next, it will be shown, how it's possible to implement some of the components of knowledge description, using PHP programming language. We'll start from describing base classes for model storage:

- ***BaseModelObject*** – describes common model in the system and contains following fields *{id, user_id, created, name, description}*.
- ***BaseModelElement*** – describes common element of a model. Has following fields: *{id, name, model_id, concept_id}*.
- ***BaseElementConnection*** – describes common connection between model elements. Fields are: *{model_id, from_element_id, to_element_id, value, is_bidirectional, value_from_to, value_to_from}*.
- ***BaseConceptConnection*** – describes relation between concepts. It has following fields – *{first_concept_id, second_concept_id, type}*.

And for example, we will consider class that describe ontology model and its concepts:

- ***Class OntologyModel*** extends class BaseModelObject, so it has only one internal field – *{elements}*.
- ***Class OntologyElement*** extends class BaseModelElement and it need also only one internal field - *{model}*.

B. Knowledge manipulation

As it can be seen from KML metaontology, part, responsible for knowledge manipulation, includes operators for knowledge manipulation (or action operators). Action is understood as operation, operand — operation parameter. Currently, KML has following operators:

- ***CALL*** – invoke of mathematical and semantic modelling tools
- ***CONVERT*** – operation for conversion of objects from one type to another, e.g. conversion of cognitive model to event model
- ***RECORD, FIND, READ*** – operations for interaction with the Repository, responsible for knowledge storing, search and extraction from it.

V. Conclusion

This article considers the international project, carried out under the guidance of the Massel L.V. with the support of the EASR-RFFI funds. The applied technologies of semantic modelling are briefly described. The architecture of the Web-based information (WIS) system is presented and the components of this system are described. One of the most important components is considered – Knowledge Management Language (or KML). Its structure was shown. Also, some examples of its implementation were presented using PHP programming language. Work on WIS is in progress. Scientific prototypes of main components were developed, and their debugging and approbation is being executed.

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