Generation and Verifying of Fuel-Energy Complex Mathematical Models

O. V. Kurganskaya
Energy systems institute SB RAS
Irkutsk, Russia
e-mail: olgakurg@gmail.com

Abstract[1]

The report is devoted to solving problems of generation and verifying mathematical models of fuel-energy complex. The basis of the proposed solution is the use of logic models to the original data, highlighted in a special structure called a model's prototype. Logic models describe the structure of the prototype and mathematical models and contain the rules for the generation and verifying of text files with mathematical models in accordance with this instance of the prototype. The proposed solutions can be implemented on the basis of XML language. The ways of concept implementation is considered in the article.

1. Introduction

Fuel-energy complex (FEC) researches using mathematical modeling and numerical experiments are notable by multiple changes in basic data of mathematical model and its processing with special software tools (solvers). Thus, it is necessary to design a technology and tool for automatic generation basic data files, as well as verifying of these files before it is processed solver. The base of the proposed technology is to use logic models to the basic data, arranged in a special structure called prototype of the model.

Using the prototype allows solving the following tasks:

- The task of generation of text file with mathematical model is to create a text file in a solver format based on available data, given in the form of XML-prototype.
- The task of verifying text files consists of two subtasks. On the one hand, be verifying text file with mathematical model of a given XML-prototype, on the other hand, requires verifying of mathematical model of the specification of its structure (from a formal point of view).
- In addition, compliance is necessary to verify the existing prototype given specification of its structure.

The report consists of three parts. The first part describes the basic scheme of the proposed technology, as well as description of the main elements of the scheme. The second part presents the logic models used in the proposed approach. The third part addresses issues of software implementation of the presented approach.

2. Concept implementation and data organization

The base of the proposed approach is a representation of the prototype model in a XML-file. This file contains a description of mathematical models (one or more) basic data arranged in a set of characteristics, in accordance with the conventional territorial-production structure [2]. The XML- prototype can be built with ontology editors (Protégé, OntoEdit, etc.) or generated from data sources such as databases, Excel files, etc.

Let's consider an example. Fig. 1 shows a fragment of the structure of XML file described an FEC, considered in terms of territorial, industry and technological unity.

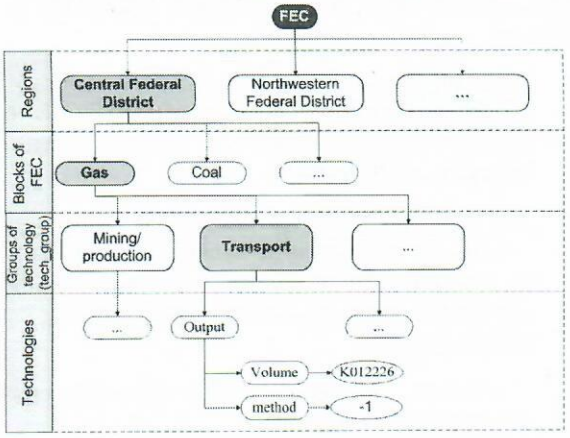

Fig. 1. Fragment of prototype structure

Proceedings of the 12th International Workshop on Computer Science and Information Technologies CSIT'2010, Moscow – Saint-Petersburg, Russia, 2010

This XML-file consists of the following levels:

1. FEC
2. Regions.
3. Industries.
4. Technology groups.
5. Technologies (transport consumption, production, etc.).
6. Etc.

At the lower level of the prototype are the numerical characteristics of objects FEC used in generating of mathematical model – consumed / produced volumes, the coefficients input / output, etc. This characteristic can be defined directly or derived from data sources such as databases, spreadsheets, text files, etc.

Description of the structure of XML-prototype required generating copies of the prototype, corresponding to the description of specific states of FEC and verifying of existing copies of the prototype is carried out in a logical model, details discussed below.

Text file with mathematical model, as noted above, has a special solver format. In particular, the mathematical model for the study of FEC subject to energy security is a linear programming problem in standard form. This linear problem consists of the following elements: the objective function, restrictions and conditions for no negativity of variables. Description of the model structure can also be done using a logic model.

For solving the above tasks also need a logic model that establishes a correspondence between the prototype and mathematical model. This alignment is necessary for solving the problem of generating models, and for the purpose of verifying compliance with the text file with mathematical model and model prototype.

Fig. 2 shows concept implementation of the solution of tasks on the basis of the proposed technology is as follows:

- The task of generating text file with mathematical model is solved by the use of XSLT file built processing logic model for the generation and verifying of this text file.
- The task of verifying compliance with a given structure of the prototype is carried out by applying the specifications of the prototype structure (logical model) the language of XML Schema to an instance of the prototype.
- The task of verifying compliance with a given model structure in a similar way.
- The task of verifying compliance with the prototype model is solved by applying the logical model for the generation and verifying of the language XML Schema to XML-description of the prototype and mathematical model.

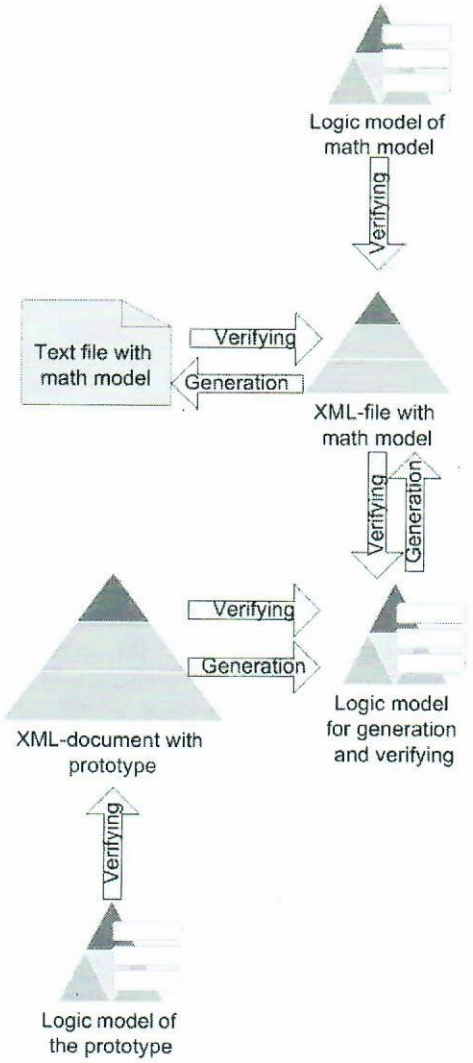

Fig. 2. Scheme of concept implementation

3. Logic models

Let's consider a more logic model proposed above. The duties of these models:

- Description of the structure of the prototype and verifying copies of the prototype in accordance with this description.
- Description of the structure of mathematical models and verifying of its model structure in accordance with this description.
- Description of compliance mathematical model to the prototype and generation and verifying model in accordance with these rules.

To describe the logic models can be used first order logic with function symbols [3], in which there are:

- Variables and constants: {*x*, *y*, *z*, ...} and {*tek*, *region*, *model*, *var*, ...} to denote the elements of the prototype model and the numerical characteristics of these elements.

- Predicate symbols: $\{P, A, R, = \ldots\}$ to denote the relationship parent, ancestor, root (of prototype or models), etc.
- Function symbols: $\{+, - \ldots\}$.

Consider the example. Fragment of a logic model that describes the structure of the prototype shown in Fig. 1, is as follows:

$$\forall x, y : Element(Model, x) \wedge Element(Model, y)$$
$$\wedge A(constr, x) \wedge A(constr, y)$$
$$\wedge A(coeff, x) \wedge A(\text{var}, y) \wedge Next(x, y)$$
$$\Rightarrow \exists z, w : Element(tek, z) \wedge Element(tek, w)$$
$$\wedge Level(z,7) \wedge Level(z,7)$$
$$\wedge z = x \wedge w = y$$

4. Concept of software implementation

Software implementation of the proposed approach can be made on the basis of extensible markup language XML [4]. Let's consider the concept of implementing, monitoring compliance with a text representation of economic and mathematical models of a given structure (Fig. 3). Software implementation of solving the verifying of conformity of the prototype given the structure and verifying of compliance mathematical model to the prototype have a similar scheme.

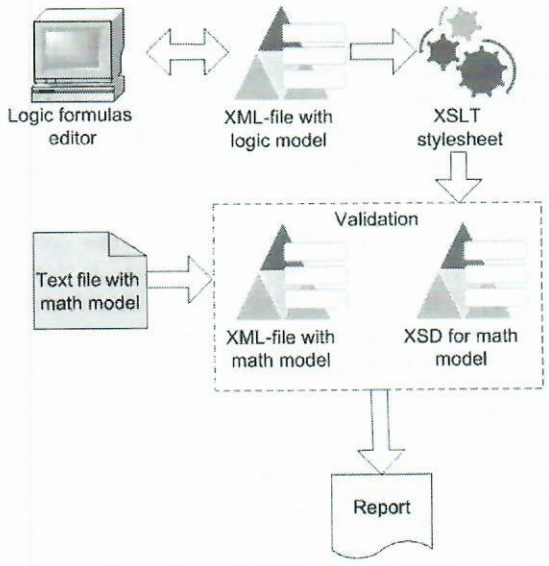

Fig. 3. Scheme of software implementation

The first stage determines the structure of mathematical model as a logic model using the editor of logic formulas. The logic model is an XML-document. Then this XML-document processes with XSLT style sheet, which generates a description of the mathematical model structure language XML Schema (XSD). In addition, one has to build the XML-document with mathematical models from text file using, for example, regular expressions mechanism. At the last stage XML-document with mathematical model is verifying using XSD.

5. Conclusion

- The report suggested that the tasks of generation and verifying of text presentation of the economic and mathematical models of the energy industry.
- The approach to solving these problems on the basis of logic models and XML-prototype shows the concept of the software implementation of the proposed approach.
- The experimental software that implements the proposed approach, developed as an extra agent in a multi-agent software package "INTEC-M" [5].

Acknowledgments

This investigation is partially supported by Russian Foundation for Basic Research grants: 08-07-00172, 10-07-00264 and by RAS Presidium Program № 2.29.

References

1. Bushuev V. V., Voropai N. I. "Russia's energy safety". Nauka, Novosibirsk, 1998.
2. Rudenko Yu. N. "Reliability of Power Systems". Energoatomizdat, Moscow, 1994.
3. Ershov Yu. L, Palutin E. A. "Reliability Mathematical logic". Nauka, Moscow, 1979.
4. Holzner S. "Real world XML", New Riders Publishing, 2003.
5. Massel L. V., Arshinsky V. L., Fartyshev D. A. "Intellectual information technologies in energy security problem research". In: *Proc. of 11th International Workshop on Computer Science and Information Technologies (CSIT'2009)*, Vol. 1. USATU, Ufa, Russia, 2003, pp. 25–28.