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THE ISSUES OF APPROACHES INTEGRATION TO SUBJECT DOMAINS METAMODELING

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This article discusses different approaches to metamodeling, show in place of these traditional models and set the direction of integration and sharing of these approaches.

Keywords: subject domain, metamodel, information system

Introduction

When designing and maintaining various applications information systems (IS) was used and are used concept models (mathematical, structural, information, etc.) and metamodels of both the information systems and subject domains (SD), to solve or support decisions problems over which these information systems are created. Moreover, a different, sometimes contradictory, meaning is put into the concept metamodel.

Information models and "classical" metamodels

The concept of information models is used quite widely now, although not clearly defined. One of common formulations of this concept states that as the SD model, which is supported by IS, is materialized in the form of properly organized information resources, it is called information model [1]. However, each information system developer uses this concept in the context own needs to describe of those or the other aspects of SD. It can be:

1) description of the information flows, that
   - circulating between the information system elements (including users of this information system);
   - coming in to the subject domain, coming out of it, or circulating within the SD;
2) description of the subject domain structural elements, i.e. entities, relationships between entities etc.;
3) integration of first and second views of the information model.

The first approach is used most often to describe an information systems in general, their components, their interaction between each and with the surrounding concrete information system world. The second most applicable when designing a databases (DB) and data warehouses (DW). Due to that a database is a kernel of any IS, and therefore issue structuring and manipulating the information stored in DBs and DWs is one of the most pressing, on this aspect should dwell more detail.

Entities in the models of this type are represented as abstractions are described by their properties, to which, in the case of object-oriented information model, we add and methods (i.e., operations, functions, events) that are characteristic for this entity.

In presenting in the database these properties are mapped into the appropriate attributes with the addition of their types, characteristics, formats etc. Sets these attributes values describe specific instances of the entity. That is, sets of the properties specific values of entities (else the entities instances or the items) in the aggregate contain information about the subject domain. Accordingly, themselves properties or attributes is data about data that meets the definition of metadata.

Thus, the information model (or simply the model) is based on metadata about the elements of SD. If to collect an all the metadata description that describe the specific entity at several SDs or describe part or all elements of the specific subject domain, the next-level model or meta-model, because it contains data about the metadata that describe the data about elements of SD, will be received. In the first case it is an entity representation in the all available at given time the SDs, for which in [2] the concept and definition of universal entity were introduced. In the second case the SD is described, which can be represented as an object or entity of the higher-level SD [3].

The idea of creating and using metamodels expressed by many researchers. Moreover, it's proposed even ontology be seen as a metatheory [4]. Recent developments have been embodied in the specifications of Common Warehouse Metamodel (CWM) and Meta Object Facility (MOF) [5, 6], which implement a four-level architecture of metamodels, which became a classic: *meta-metamodel – metamodel – model – data*. *CWM* is a standard that describes the exchange of metadata when using Data Warehouses technology, Business Intelligence, Knowledge Management. Relying on the basic metamodel the standard adds metamodels for relational, multidimensional and table data, as well as for transformation, OLAP-functions, Data Mining and Data Warehousing, including the processes and operations. MOF defines common interfaces and semantics for interacting metamodels and a set of IDL-transformations. MOF is an example of a meta-metamodel or a model of metamodel as subset of the modeling language UML.

Hierarchical metamodels of the complex-structured subject domains

Approach proposed by the author of this article in [2] differs from the traditional view to the metamodels, that especially the not just different description languages are touched on, and the different levels of SDs and their respective models are viewed. In such a model can not be limited to four levels. Accordingly, the *metamodel of k-th level* is a mathematical, information or a structural model of the SD or the object whose elements are described by metadata of corresponding level. According to this definition, the database or, more precisely, the traditional database information model is a subject domain metamodel of 0-th level.

To remove restrictions on the levels number of metamodels was proposed also in article [7]. However, it also not dealt with the representation of the subject domains hierarchy, the manipulating their metamodels and the influence of the subject domain levels on their entities representation.

Obviously, it's necessary to look on the metadata wider than stated in the definitions above. "Meta ... (from Greek: *μετά — between, after, over*) is part of compound words, which denotes the passage of something, a transition to something else, change of state, the transformation of ..." [8]. According to this definition of the prefix "meta-" the metamodel should describe also the dynamics of the SD, its evolution or, at a minimum, include the opportunity to refine information about the SD.

DB, as a result of structural and information modelling of SD is the core of any IS. Therefore, the metamodel of SD is an effective tool for building IS, allowing to develop a database over time. That why in [9] it was proposed when DB designing to pay attention not only to model of systems and associated with them SDs, which are often unique, but also on the metamodels, their development and manipulation them.

A similar idea was developed in the technology of DSM (Domain Specific Modeling) with the metadata interpretation [10] and its implementation. In addition, in 1990 J. Mylopoulos was proposed the language *Telos* [11], designed to solve the problem of formal representation of knowledge about the many worlds, related to a specific IS. This language contains object-oriented structure that supports aggregation, generalization and classification; processing attributes; an explicit representation of time; means for the constraints integrity determining and deductive rules. However, this language just as the language UML, does not include mathematical operations with the structures that describe the subject domain and, therefore, requires the subjective factor intervention at each modification of such structures (models) or in the modeling of complex-structured SDs.

Metamodel representation is possible by using various mathematical apparatus. Naturally, the choice of apparatus determines a set of mathematical operations that can be performed on metadata.

To the information model representation is often used a graph form. To the model processing is applied a corresponding mathematics, which, however, ignores the graph representation of this model, that is used exclusively for the model visualization.

So the a relational DB theory apparatus is one of the most developed, namely, the relational algebra, which is designed to work with metadata and the data they describe. Originally, however, that mathematics is not enough to work with metamodel of level above 1. In particular, it ignores the mass problems that are solved over the subject domain, and does not include graph and hypergraph representation of the model.

That why in [12] the author of this article stated that a SD is described by triplet $(E_i(d_j), V_i(d_j), P_i(d_j))$, where E is a set of different classes objects sets, V is set of relationships between them, P is the set of mass problems to be solved over the SD. Moreover, the set E consists of: a set of active objects H purposefully influencing each other and to other objects of the environment; a set of passive objects which are the only influence receivers and associated with research and production complex Q, associated with a given SD; and a set of objects O that are resulting of intellectual activity.

Accordingly, the operations for such a representation that take into account the peculiarities of the high-levels metamodels had been proposed in [12, 13, 14]. They are built on the integration of the following mathematical apparatuses.

To resolve the contradictions between the DB and the SD associated with the SD evolution, the *graph theory* as a mathematical tool is used when the SD metamodels development. At that the operations on metamodels are some operations on graphs, adapted to the fact that elements of their operands are sets of mass problems to be solved over the SDs and metainformation about the objects of these SDs represented by the graph nodes.

One element of this adaptation is the use of the suboperations (nested operations) on the SD metamodel. These nested operations are based on *set theory*. Accordingly, the operations on the SD metamodel are operations on sets, modified in view of the fact that their operands will be metainformation.

Finally, the metadata themselves are implemented as *multi-dimensional relations*. From the practical point of view, this approach allows the use of existing DBs, their functions and commands to manipulate tables and warehouses to perform operations on metadata.

Conclusions

From these approaches to metamodeling clearly that CWM specification or DSM (or language *Telos*) are effective for the initial design of IS, to determine its structure and interaction with the corresponding SD. At the same time the hierarchical metamodeling of SD is advisable used to build the DB and multilevel DW, since it allows to consider the evolution of SD and the mass problems that exist or arise over the SD with complex structure. Obviously, the next step in the evolution and use of metamodeling is the integration of these approaches.

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ВОПРОСЫ ИНТЕГРАЦИИ ПОДХОДОВ К МЕТАМОДЕЛИРОВАНИЮ ПРЕДМЕТНЫХ ОБЛАСТЕЙ

В данной статье рассмотрены различные подходы к метамоделированию, показано место в них традиционных моделей и определено направление интеграции и совместного использования этих подходов.

Ключевые слова: предметная область, метамодель, информационная система

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ПИТАННЯ ІНТЕГРАЦІЇ ПІДХОДІВ ДО МЕТАМОДЕЛЮВАННЯ ПРЕДМЕТНИХ ОБЛАСТЕЙ

В даній статті розглянуті різні підходи до метамоделювання, показано місце в них традиційних моделей і визначено напрямок інтеграції та спільного використання цих підходів.

Ключові слова: предметна область, метамодель, інформаційна система