Ontological Design of Informational Systems for Legal Applications

L.Y. Ismailova
Department of Cybernetics
Moscow Engineering Physics Institute
Moscow, Russia
e-mail: larisa@jurinfor.ru

S.V. Kosikov
Department of Cybernetics
Moscow Engineering Physics Institute
Moscow 115409, Russia
e-mail: larisa@jurinfor.ru

Abstract[1]

Further development of information processing means including features for search, analysis and classification in areas of great doctrinal variety requires, as one may see, choice of specific conceptual modeling tools adequate for considered tasks. Such areas include law activity, political science, sociology and so on. In spite of multiple steps in this direction, it seems that until now there are no finished solutions adequate for considered tasks. Investigations [2, 4, 6] allow determining main characteristics of problem domain class that lead to major difficulties during modeling.

1. Characteristics of Social Science Problem Domains

There are three such characteristics. The first is multi-aspect structure that presupposes the necessity of problem domain consideration from different points of view. Such points can be either mutually supplementing or mutually exclusive (see fig.1).

The second is essentially dynamical character of problem domain that presupposes not only data change during task solving, but also change of data interpretation system (see fig.2).

The third is intentional character that presupposes firstly simultaneous coordinated use of construction of different abstraction level during task solving and secondly connection of different (generally speaking, partial) data interpretations with different objects of problem domain (subjects, time moments, law systems etc. (see fig.3).

So those are considered as assignment points [6]. Problem domains having enumerated characteristics can be considered as social science problem domains [3].

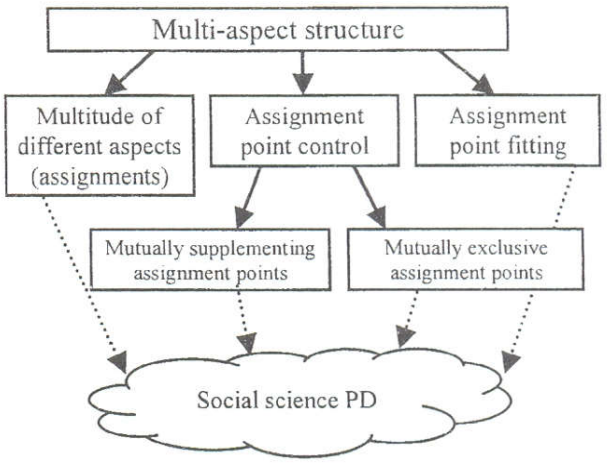

Figure 1. Multi-Aspect Social Science Problem Domains

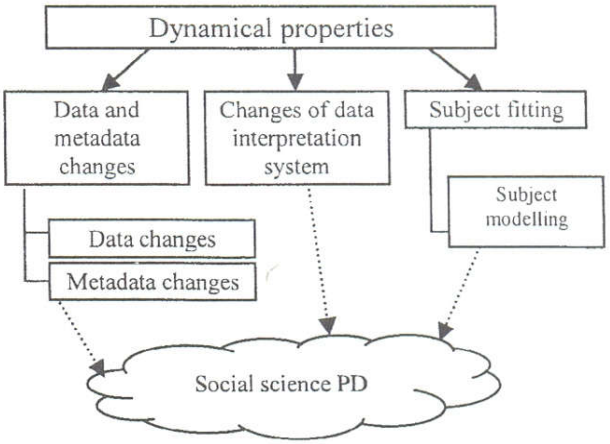

Figure 2. Dynamical Social Science Problem Domains

Now we consider the proactive nature of the information systems in an area of social science.

1.1. Requirements for Proactive Systems

Attempts of extension of system modeling methods application areas, especially conceptual modeling, lead to

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a necessity of more accurate development of conceptual basis for model building means.

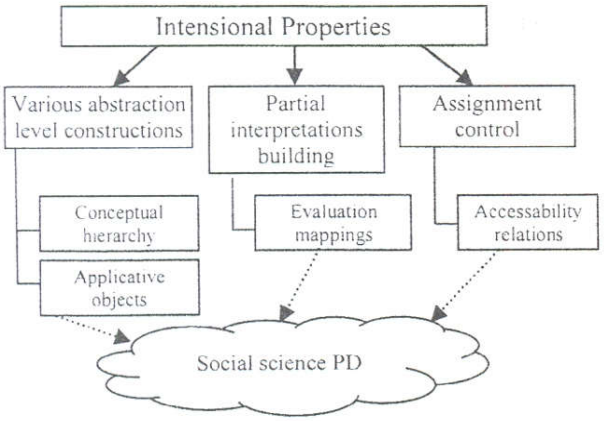

Figure 3. Intentional Social Science Problem Domains

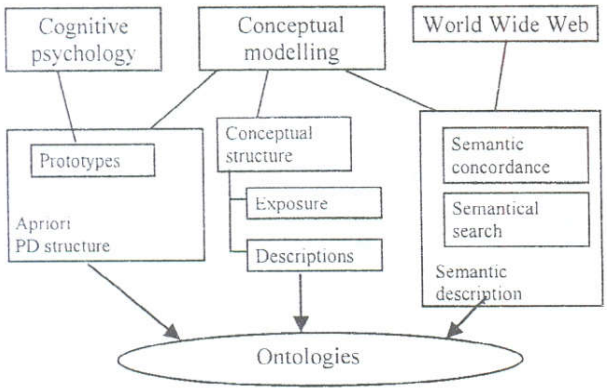

Figure 4. Approaches to Ontology Definition

Multiple and generally successful applications of general conceptual modeling means gradually strengthen the opinion that basic technique of model building in every concrete case must be extended by mechanisms more or less problem oriented. In any case, such contemporary projects in the area of computer modeling, that are arrogant enough, as full-scale business real time systems building for complex problem domains and creation of proactive systems and technologies providing role diversity, undoubtedly raise such claims.

1.2. Necessity of Semantic Extensions

Classical conceptual modeling techniques are first oriented on syntactical fixation of problem domain structure, while support of semantic aspects left to concrete interpretation mechanism [5]. On the whole it leads to lack of systematical approach to semantic mechanisms and cannot provide uniformity in its implementation.

Such a method frequently restricts possibilities of semantic refining of interpretations and their adaptation to the modeled problem domain and to the methods of fixation and extraction of data, metadata and their adjusting procedures.

2. Approaches to Ontology Definition

One of the most productive solutions is a building of meta-theories universal enough providing variety of possibilities on all stages of design and support of problem domain modeling oriented systems. On this way several investigators define and use ontologies. Possible approaches to their definition are shown on fig.4.

But term 'ontology' in most cases is used for conceptual modeling means extension in the area of semantic description of problem domain concept system. Even attempts to establish appropriate standards are made, that seems to be connected with the most widespread use for automation of multiple library resources.

It seems however that such use of this term does not allow to expose all content potentially existing in its meaning, especially in cases when the task is not only information resource creation but automation of selection procedures in poorly formalized problem domain.

2.1. Semantic Definition of Ontology

In the boundaries of the most general definition of semantic as a method of attaching values to syntactically organized data ontology can be defined as the method of formalized definition of classes of conceptual modeling means semantics, means for step-by-step refining of semantics and means for construction of semantic with required properties [3, 5]. Acceptance of the ontology presumes selection of general properties of conceptual modeling system, that is a collection of problem domain description means for linguistic and conceptual level.

2.2. Ontologies and Interpretation Classes

Ontologies (in formalization represented in [5]) determine interpretation methods and strategies and corresponding classes of conceptual language expressions. In general case ontology determines not only expression classes but also methods of class construction that can either be inherited by problem domain definition conceptual language or stay inside ontology. Besides methods of connection interpretations to expression classes and methods of step-by-step refining of such connection can be defined. So ontologies provide a conceptual basis for definition, discussion and construction of semantic means for conceptual model classes and for systematic construction of conceptual modeling means with given semantic.

2.3. Modeling Systems

Analysis of the approaches to solving of problems arising in social science problem domains substantiates the approach to their solution on the base of conceptual modeling method development and allows raising a problem of specialized modeling information systems creation for such problem domains. Modeling character of such systems is determined by solving task through creation and investigation of problem domain conceptual

model with respect to their multi-aspect, dynamic and intensional character. Concrete tasks can include prediction of processes in problem domain in accordance with model dynamics, selection and explanation of possible or preferable by some criteria way of operation in problem domain, teaching or training of a human being to select actions and their sequence, or may have another similar character depending on concrete system goal.

3. Using Ontologies

Let us see in more details process of information system development based on ontology approach. For more definite and substantial task discussion let us consider problem domain class that seems to be most representative for tasks of a given type. On the other side we attempt to make a step aside of concrete tasks for not to 'sink' in technical details unessential for considered approach to ontology definition and ontology based information system design.

3.1. Ontologies for Legal Applications

Practice of modeling systems development shows that the problem domains most interesting from the point of view of representation and modeling of particular features in problem domain and ways of their processing but for the same reason the most difficult for modeling are those connected with the solving the tasks of law. Really, in juridical practice the necessity of taking into account different points of view is especially typical, while in other domains this feature is mediated by the used paradigm. Juridical tasks also demonstrate the necessity of interpretation system changes during task solving, i.e. dynamical character as described above. Finally, intensional character of juridical tasks also can be distinctly observed in most applications [6] and make difficulties for juridical problem domains modeling with traditional methods.

3.2. Subject of Ontology Modeling

In accordance with general approach problem domain modeling begins with ontology definition. This definition is expedient to perform taking into account concrete task typical for considered problem domain and picking out properties that allow consideration of the task as a representative of a task class. It is also necessary while defining ontology to take into account availability of resources in the wide meaning (for example, presence of convenient instrumental modeling tools and staff able to use them).

3.2.1. Representation of the Subject

We shall call below the subject who defines an ontology, *ontologist*. Let us mark that ontologist is usually physically represented as minimally two subjects – specialist in the area of editing, modifying, refining an ontology using appropriate instrumental means and specialist in given problem domain experienced in details of tasks of a given class and perceiving ontologically significant purposes. Organizing of communication between physical subjects (its legal, administrative and organizational aspects) for ensuring of successful functioning of virtual subject – ontologist – remains out of boundaries of this paper, mainly because there is a huge amount of literature on this question (see, for example, [2]).

3.2.2. Functions of Ontologist

Main function of ontologist is to refine methods and tools for description of informational structure necessary for task solving. First stage of this process is a definition of general approaches to knowledge representation, adequate enough for discussion of structure to come and ways to create it. Really, the same task (task class) can be discussed, for example, either in boundaries of rule-based knowledge representation, or using entities and relations, or basing on objects, or in problem-oriented terms. Resulting informational systems will have significantly different structure, different interface, and in most cases also different efficiency. So this stage deserves an attention and should not be made by default, as it is made often. In some sense it is necessary to select ontology on the task base but not to adjust the task to ontology, though in practice it is often not so easy.

3.3. Conceptual Elements of Ontology

After that ontologist with using of defined terms determines a composition for conceptual model and rules for its semantics definition. Semantics definition itself usually is performed later, possibly even in process of informational system support, though on this stage methods of semantic definition, basis for comparison of semantics and conditions of their comparison are created. It is essential to determine moments and methods for evaluation of proposed constructions and rules for assignment structure building. Just in this area wide diversity of methods is usually described not in full details [1]. Variants of evaluation methods definition are well investigated for more simple cases that arise, for example, in the area of programming languages semantics, and often are not specifies during design of instrumental means for informational systems. The simplest technical solution on this stage is using of applicative type instrumental means. Let us remark that exactly this solution was intuitively used in most works on intellectual systems, where applicative languages, particularly LISP, were used as a base language. Conceptual transparency of this approach is evident.

3.3.1. Category Structure of Ontology

The initial assumption of proposed method of ontological design is that modeling problem domain carries a structure of a category. This assumption allows using for task class solving a formalization of design process by category means, corresponding instrumental tools and methods. Let us remark that this assumption does not restrict a general character of the approach because every widespread traditional technology as a rule presumes

using of a set theory. But sets also form a category, and even particular enough type of category (technically even more special than topos [7]), and hence conclusions about problem domain objects modeled in such way are less interesting for dynamical and/or intensional applications.

3.3.2. Conceptual Modeling Means

Selection of conceptual means for model building is performed on this base. In this case independently of selected or even constructed during problem domain modeling variant of frame knowledge representation model, building model based on concepts and frames is coordinated with categorical point of view from the beginning. Concepts correspond to the objects and frames to the arrows of basic category. Establishment of such correspondence allows imparting to model a computational character, i.e. building evaluation mechanism in applicative form, that allows using while building well established and widely known techniques of functional languages implementation.

Building model based on the rules, contrary, proposes building of evaluation mechanism in the form of logical inference system. Semantics of such mechanism is defined on the base of some logical system (classical or intuitionist, first or higher order and so on). It is necessary to remark that means for description of a semantic and its support are elaborated in this case not so detailed as in previous one.

Category in the logical approach to problem domain description arises during model building (in the sense of mathematical logic - model theory) for theory of first or higher order defined by rules. Adequate selection of base category provides building of a model which properties are given in accordance with solving task peculiarities.

Selection of conceptual model building means configuration in the form of semantic network keeps an intermediate place between ones mentioned above. For separate model constructions in this case both applicative and logical interpretation methods are possible. Concrete method of semantic building in this case depends essentially on selected configuration of semantic network constructions.

3.3.3. Integrity Constraints Definition

Separate (and one of the most interesting) question while modeling means building is a selection of model integrity constraints definition and manipulation tools. Such tools may be either defined separately (as specialized mechanisms, like in relational model), or implemented by general conceptual modeling mechanisms (for example, bases on rules). Exceptionally important circumstances are method of integrity constraints reflection in base category structure and organization of switching among different methods of their mapping during task solving, preserving semantically significant elements of a model.

For example, when conceptual modeling means are built basing on variants of intuitionist logic, the acceptance of usual model intuitionist models restriction becomes necessary – definition area of a model can be only extended while time is passing.

This restriction is not fulfilled in most juridical tasks. Hence in some cases using of more weak logics models becomes necessary. General scheme of ontology use is shown on fig. 5.

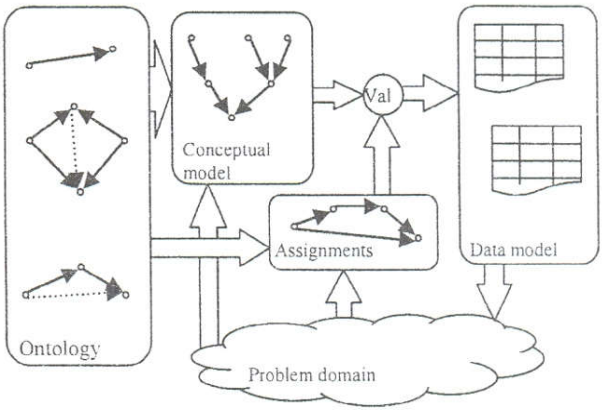

Figure 5. Ontology Using in Conceptual Modeling

3.4. Epistemological Elements of Ontology

Besides conceptual model building means definition, ontologist also determines means for assignments structure definition in problem domain models of a given class. This structure does not propose definition of particular assignment points which should be defined on later stages of system design or even during its using (if resulting ontology provides generated assignment points). Instead ontologist defines a collection of assignment point processing means. First of all a decision of different assignment points support necessity must be taken. The matter is that in simple cases assignment support can be leaved to the user discretion and not to be represented in the system explicitly (for example, most universal text editors do not differentiate editing tools on creating document types, and specialized ones usually are essentially restricted on such document types).

3.4.1. Using of Evaluation Mappings

For definition of means for data processing inside one assignment point an ontologist defines types of conceptual language expressions for which valuations can be made, character of corresponding evaluation mapping and order of its application. In practical sense this will determine 'boundaries of interpretation' for results of problem domain modeling. Evaluation mapping can be defined once (during ontology creation) as in most programming systems. In other cases several evaluation mappings can be provided, and system designer must select one of them later. Also tools for evaluation mapping construction can be provided. Such construction usually is made by recursion on conceptual object structure. This way corresponds well to applicative paradigm of ontology building and gives an applicative character to resulting models.

3.4.2. Access Relations Definition

In the case of providing work with multiple assignment points it becomes necessary also provide a possibility of taking into account correspondences among them. Analogically to previous case at first decision must be made, is it possible or not to establish such correspondences because in the case of social science informational systems there are no universal structure simple enough even in the case of multiple assignment points. Definition of formal conditions of transition between assignment points typically becomes a non-trivial task. In some particular cases, however, it is reasonable to leave to the user setting of connections among assignment points and do not support it explicitly inside the system.

Interconnections among assignment points (more strictly mathematically, relations on assignment points set) in special literature are called usually *access relations*. If the decision of their establishing is made, it becomes necessary to solve a question about their quantity – one or several relations, about their correspondence, about permission of composition of such relations. Interesting question from both theoretical and practical point of view is a question on support of access relations, their refining, manipulation, and modification. Solving the question on necessity of access relations' properties in design of concrete informational system is technologically significant and important project decision. In general case properties are determined by used mathematical model and can include reflexivity, transitivity and so on. Setting of access relations' properties makes logic supported by basic category of a model more precise.

3.4.3. Intentional Expressions Definition

Then it is necessary to determine a connection between established epistemological modeling methods (i.e. assignment points and access relations definition methods) and conceptual modeling means. Significant aspect of this interconnection is a definition of variants of actions performed in case of change of the assignment point, i.e. transition through access relation. One of the main tasks here is determination of expressions which values have to change. These expressions can be all of some conceptual classes, or expressions marked in some way.

Method of such expressions determination corresponds to the type of modal logic [7] used for mathematical model building. Let us remark that language of such logic can in particular cases use modal operators or terms, what corresponds to ontological interpretation above.

3.4.4. Assignment Point Construction

Besides it is necessary to consider required methods of new assignment point construction. Let us remark that as a rule new assignment point is not created 'from scratch' but is constructed from one or more existing assignment points. For such assignment point construction rules have to be established; evaluation mappings defined in new assignment point are of especial interest. In general case evaluation mappings are modified from original assignment points and in this case rules giving limits of modification should be defined. Also it is necessary to specify precisely in what access relations is the new assignment point (among other, are such relations generated automatically or must be set up independently).

3.4.5. Assignment Point Setting Methods

Finally it is necessary to provide methods for assignment point fixation in use of the system — whether such fixation takes place automatically (for example, in accordance with a stage of task solution), or by user requirement or in some other (for example, combined) way. A special case of such fixation is a user refusal of assignment. This is a final step of assignment structure definition means in ontology boundaries.

3.5. Results of Ontology Definition

So ontologist performs definition of formalized description methods of semantic classes for conceptual modeling means, step-by-step semantic refining means and means for construction of semantic classes with given properties. As a source data for this work he uses data on tasks of a given class. In real situations these data typically are unstructured initially. They are represented as a heap of materials on different containers in different formats. On the earlier stage of informational system design data can be represented either independently from particular language (for example, as photos, videos an so on) or using some language. This can be natural language (that corresponds in legal application problem domain such data as legislative acts text, scientific works, educational supplies, materials of particular cases and so on) or one of formal languages (HTML, XML, language of defined descriptions).

4. Goals and Advantages of Ontological Approach

It is necessary to remark that ontologist on this level does not perform full processing of data necessary for concrete task solving. His goals are (1) decision what data and in what way may be and will be used in task solving and (2) determination of possible data representation during the latest informational system design. For example, here the decision can be made on using of prepared materials of concrete cases or creation of special imitational materials, on using graphical materials in some computer-oriented representation, on system of references to scientific materials etc.

The aggregate of project decisions made by the ontologist determines the specialization of informational system design method that should be used later for concrete informational systems building. Procedure of ontology definition given above also provides selection of instrumental means configuration for later informational system design.

5. Conclusion

The main results may be indicated as follows:

- A general applicative computational model gives the opportunity to establish the embedded systems with the features for social science such as subjects, time, circumstances etc.
- An idea of cross-point identification gives the desirable semantic means.
- A set of feasible concepts can be rearranged with the pre-defined "dimensions" giving rise to practically meaningful ontologies.

Acknowledgments

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