Designing Features of Applied Ontology of Integrated Expert Systems' Typical Architectures Using the Intelligent Software Environment of the AT-TECHNOLOGY Workbench

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Abstract: A new stage of experimental research is described, devoted to the application of an ontological approach to automate the design of software for various classes of intelligent systems, in particular, integrated expert systems (IES) developed on the basis of an original problem-oriented methodology and an intelligent software environment of the AT-TECHNOLOGY workbench. The main emphasis is on the features of building an extended technological knowledge base by including a new component in its composition in the form of an applied ontology of typical IES architectures, which provides a logical interconnection of all components of the technological knowledge base and effective interaction with an intelligent planner in the process of prototyping IES. As an example, a fragment of an applied ontology of typical architectures, constructed for tutoring IES, is given.

1 INTRODUCTION

The concept of the ontology of standard architectures of integrated expert systems (IES) (Rybina, 2021) is an evolution of the problem-oriented methodology for designing IES and the intelligent software environment of the AT-TECHNOLOGY workbench (Rybina, 2008), designed to automate and intellectualize software design processes of various classes of IES, especially at time-consuming stages of system analysis.

A complete description of the considered methodology and technology of designing and developing applied IES is given (Rybina, 2008), and it is necessary to indicate that the principal feature of this methodology is the conceptual and software modelling of the architectures of the developed IES at each level of integrational processes in the IES, which is effectively supported by the powerful functionality of the intelligent planner using great opportunities of the technological knowledge base (KB) (Rybina, 2019), which includes a huge set of specifications of different standard design procedures (SDP) for the design of the most common IES architectures (static, dynamic and tutoring IES), a set of operational and information reusable components (RUC), as well as an applied ontology of typical IES architectures.

The main prerequisites for the expansion of technological KB by creating an ontology of different typical IES architectures were, on the one hand, a significant amount of accumulated information and software of various classes of IES developed in recent years, and on the other hand, in the context of interaction with an intelligent planner, the need to reduce the accessibility to semantically heterogeneous RUC with implicit functionality when their search and initialization in the conditions of the implementation of a specific SDP.

In general, if we consider new approaches to automation and intellectualization of software system design processes using or under the control of ontologies (Rybina, 2021), then the place and role of ontologies here is significantly determined by the level of complexity of the architecture models of the

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systems being developed, the availability of adequate life cycle models (LC) and semantically correct reflection of the basic design processes at all stages of LC taking into account the ontological representation of the projected architecture, composition, structure and specifications of individual components and the relationships between them.

Nevertheless, despite a wide range of works on ontological engineering (Calero, 2006), (Happel, 2006), (Bossche, 2007), (Jabar, 2019), (Horoshevskij, 2019), (Erzhenin, 2020), (Negoda, 2021), etc., issues related to the development of a significant and semantically adequate ontological model of software system design processes, in particular, intelligent systems, are poorly considered. So the expansion of research in the framework of intelligent technology creation for designing an IES as a common class of intelligent systems with extended scalable architectures is especially important today, including the details of combining the methods of intelligent planning with an ontological approach (Rybina, 2019).

This paper discusses the results of an experimental software study of the actual structure of the considered in main theme applied ontology, the model and design methods of which allow us to jointly take into account the semantic features of the architecture models of the designed IES and the features of component-by-component functionality in the form of a set of RUCs for each SDP. It should be noted that since the greatest number of software components and tools that have been tested and reengineered as part of the AT-TECHNOLOGY tool workbench and designed in the form of operational and information RUCs have been accumulated for the implementation of the tutoring IES architectures, the corresponding SDP "Designing tutoring IES and web-IES" was selected as the base test field for various studies and experimental software modelling.

2 BRIEF DESCRIPTION OF THE ONTOLOGY MODEL AND FEATURES OF APPLIED ONTOLOGY DESIGN

As it was shown in (Rybina 2021), the choice of the basic model of the ontology of typical architectures was greatly influenced by the positive experience of creating several ontologies of courses/disciplines for tutoring and practical use in the educational process, the development of which was carried out on the basis of a model in the form of a semantic network of a special type (Rybina, 2017), (Rybina, 2022).

Therefore, a modified semantic network is used here as an ontology model, but of a simpler form (Rybina, 2021) (Figure 1):

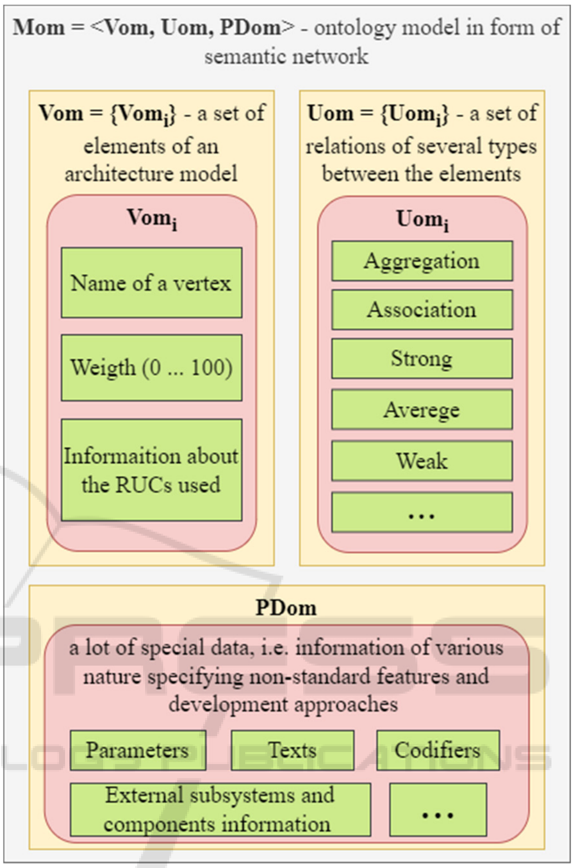

Figure 1: Ontology model in from of semantic network.

Accordingly, the actual applied ontology (Rybina, 2021) is reproduced in the form, shown on Figure 2:

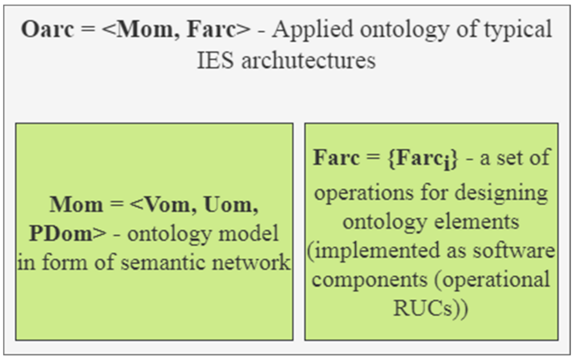

Figure 2: Applied ontology.

Now let's briefly consider some aspects of designing the actual version of the applied ontology of various typical IES architectures, the main purpose and purpose of which is to take into account and reflect at different levels of the ontology the features and logical relationships of the architecture model of the projected IES, as well as the specification of methods and algorithms implemented in the corresponding RUC.

It should be noted here that the architecture model of the prototype of the IES, represented in the form of a hierarchy of extended data flow diagrams (EDFD) (Rybina, 2008), is one of the important components of the process of prototyping of the IES, due to the fact that its order has a strong effect on the prototype of the IES and its capabilities for the implementation of a specific class of tasks to be solved. The emergence of architectural elements at different levels of nesting due to the implementation of multi-level integration processes reproduced in the EDFD hierarchy required the use of different non-trivial approaches and solutions, including a set of plural information and operational RUCs included in various software tools of the AT-TECHNOLOGY workbench.

Therefore, the general structure and basic levels of the considered applied ontology are given in (Rybina, 2021), as well as connection (relation) types presented in that research and at Figure 1 above.

Taking into account these conceptual and functional features of IES prototyping (Rybina 2008), (Rybina, 2019), all algorithms and procedures for designing, storing and maintaining the considered in main title applied ontology as an significant section of the technological KB were developed in such a way as to make the possibility of access and comprehensive customization the appropriate RUC to perform all planned tasks with the help of an intelligent planner, depending on the features of the model the architecture of the designed IES (at the same time, a knowledge engineer can perform some tasks independently or jointly with an expert).

For automated support of the processes of designing an applied ontology of typical IES architectures, modified tools were used that function as part of the basic tools of the AT-TECHNOLOGY workbench and allow to fully implement the necessary functionality, as well as for modeling interaction with an intelligent planner (Rybina, 2019) developed tools for managing interaction with technological KB were involved.

3 APPLIED ONTOLOGY OF TYPICAL IES ARCHITECTURES FRAGMENT'S EXAMPLE (SDP "DESIGNING TUTORING IES AND WEB-IES")

As an example, we will give a fragment of the applied ontology of typical IES architectures, which shows the conceptual (logical) and program relationship between the set of standard processes for tutoring IES related to displaying the current student model, built as a result of web testing, on the ontology of a specific course/discipline and the formation of an individual strategy (plan) depending on the results obtained tutoring type (Rybina, 2008), (Rybina, 2017).

As noted above, the overall management of these and other processes in the two basic modes of operation of tutoring IES (DesignTime and RunTime) (Rybina, 2008), (Rybina, 2019), (Rybina, 2017) is supported by an intelligent planner, the SDP "Designing tutoring IES and web-IES" and a set of RUC implemented using a significant amount of various software and information tools registered in different years in the AT-TECHNOLOGY workbench and included in the subsystem of support for the design of tutoring IES.

Therefore, issues related to preliminary analysis, structural and functional identification and formal representation of all software tools and components in accordance with the basic RUC model are of great importance for designing an applied ontology of typical IES architectures (Rybina 2008). Below are the formal descriptions (concretizations) of two conceptually related RUC implementing the functionality mentioned above.

Specification of the RUC "Mapping the current student model to the ontology of the course/discipline" in accordance with the basic model of the RUC <N, Arg, F, PINT, FN> (Rybina, 2008) is defined as:

N - the name of the registered component "Mapping the current model of the student on the ontology of the course/discipline";

Arg = <Arg1, Arg2>, where Arg1 is the course/discipline ontology, (previously built in DesignTime mode (Rybina, 2008), (Rybina, 2017)); Arg2 - current student model (M1cur);

F: Arg1 x Arg2 → R - method for evaluating the results of testing students, where R = {rj}, (j = 1 ÷ m) - a set of "problem areas" of a particular student (Rybina, 2008), (Rybina, 2017);

PINT - RUC interface "Formation of tutoring strategies";

FN - the function of forming the current level of the student's competencies (Rybina, 2017).

So, the specification of the RUC "Formation of tutoring strategies" is defined as:

N - the name of the registered component "Formation of tutoring strategies";

Arg = <Arg1, Arg2>, where Arg1 = {arg1i} is the set of course/discipline ontologies, (i=1÷n), (n is the number of course/discipline ontologies); Arg2={arg2j} - set M1tech, (j=1÷p) where p - number of M1tech;

F = <F1, F2>, where F1: Arg1 x Arg2 → A - method of forming a set of tutoring strategies (plans), where A = {ai} (i=1÷k) - set of tutoring plans, where k is the number of plans; F2: Arg1 × A → B is a method for generating a set of learning influences based on plans, where B = {Bi}(i=1÷m) is a set of learning influences, where m is the number of learning influences;

PINT - RUC interface "Management of the implementation of learning influences";

FN - formation of a set of tutoring strategies containing an ordered set of learning influences.

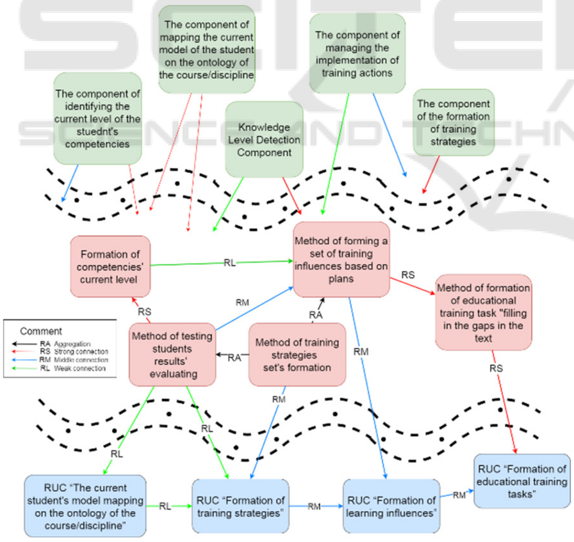

Figure 3: Fragment of the applied ontology.

Figure 3 shows a fragment of the applied ontology of typical IES architectures, the upper levels of which reflect the functional and structural features of the subsystem for supporting the design of tutoring IES, which operates in the basic version of the AT-TECHNOLOGY workbench (Rybina, 2008), (Rybina, 2017). The middle and lower levels of the ontology are formed on the basis of formal specification of the RUC.

The greatest variety of connections is observed at the levels of methods/operations, where such types of connections are used, such as, for example, connections of the RA type (aggregation) between the method of forming a set of learning influences and the method of forming a set of tutoring strategies, as well as connections of the RS type (strong) between the method of formation of educational training task "Filling in the gaps in the text" the RUC "Formation of educational training tasks" and others.

4 CONCLUSION

The ongoing research and experimental software modeling of software design methods for applied power plants with various architectural typologies under the control of ontologies are quite new for artificial intelligence technologies and software engineering in general.

It is too early to expect practical results in the field of creating effective ontological models and powerful tools and platforms for automating and intellectualizing software development processes of intelligent systems. Nevertheless, the accumulated experience and the constantly developing technological base in the form of the environment of the AT-TECHNOLOGY workbench allow us to solve the scientific and practical tasks set in stages.

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