

# Features of Development of Internet Resource for Supporting Developers of Intelligent Decision Support Systems

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**Abstract**—The paper describes the approach to development of Internet resource providing support of building of Intelligent Decision Support Systems in weakly formalized areas. In this resource the ontology is used for the formalization and systematization of knowledge, data, facilities for processing and analysis of information integrated in the resource, as well as the organization of convenient content-based access to them. Therefore, the creation of the resource is mainly reduced to the development and population of its ontology. The paper discusses the methodology for developing such an ontology, which includes methods for constructing a target ontology based on a representative set of basic ontologies and ontology design patterns. It is shown that the use of ontology design patterns allows not only to save resources spent on the ontology development, but also to provide a consistent representation of all entities of the ontology, which in turn allows to increase the clarity of the ontology and minimize the number of errors of ontological modeling.

**Keywords**—information-analytical Internet resource, decision support system, weakly formalized area, ontology, ontology design pattern

## I. INTRODUCTION

Support for decision-making in weakly formalized areas, such as medicine, power engineering or education, is currently an urgent problem. The development of decision support systems (DSS) for this class of areas is not an easy task because modern tools for the development of DSS either are not applicable to weakly formalized areas, or are unavailable due to their high cost.

The concept of complex support of the process of developing intelligent DSS in weakly formalized areas [1], which assumes providing support for DSS developers at all stages of its creation, including support at three levels: conceptual, component and information, was suggested in the A.P. Ershov Institute of Informatics Systems of the Siberian Branch of the Russian Academy of Sciences.

At the conceptual level, all groups of specialists involved in the development of intellectual DSS (knowledge engineers, programmers, experts) are provided with a unified system of concepts. In the proposed concept, the ontology of the knowledge area "Support for decision-making in weakly formalized areas" is used for these purposes.

At the component level, DSS developers (programmers) are given direct access to implementations of decision support methods (DS-methods) in the form of services assembled in a special repository.

The information level is provided by the information-analytical Internet resource for decision support (IAIR DS), which provides the DSS developers with all the necessary information about specific DS-methods, the classes of tasks solved by these methods, the possibilities and limitations of each of them, and so on.

The conceptual basis of the IAIR DS is the ontology that serves to formalize and systematize various types of knowledge, data, information resources, information processing and analysis tools integrated into information space of the resource, and to organize convenient, content-based access to them. In view of the fact that ontology plays such an important role in this resource, its creation is reduced mainly to the development and population of its ontology. For this reason, most part of the paper is devoted to the discussion of methods for developing the ontology of the IAIR DS.

## II. THE INFORMATION-ANALYTICAL INTERNET RESOURCE FOR DECISION SUPPORT

IAIR DS is an information system accessible via the Internet which integrates and systematizes the knowledge and information resources of the knowledge area "Support for decision-making in weakly formalized areas" and the means for processing and analyzing information developed within this area, as well as providing a content-based effective access to him.

As said above, the conceptual basis of the IAIR DS is the ontology containing the formal specifications of the concepts of the knowledge area of the IAIR DS, the types of information resources and methods of supporting decision-making. According to these specifications, structures for representing information on the real objects of the modeled area of knowledge, information resources to be integrated in this resource and of DS methods are being constructed. On the basis of ontology, convenient navigation through the content

of the resource and the content-based search of the necessary information are also organized.

The user can navigate along the full content of the IAIR DS, using as a conductor a tree of ontology concepts which built on the basis of a "general-private" relationship. In this case, it is possible to select an object of any concept (class) and view it in detail, as to transit to other objects related to this relation specified in the ontology. If the object description contains links to information resources or web services, the user can view their descriptions and go to the selected resource or execute the web service required by him.

The user is also has the opportunity to search for objects of a certain class. To do this, he can set restrictions on the values of the attributes of the desired instances of the selected class and on the values of the attributes of the instances associated with them using an ergonomic interface generated on the basis of an ontology.

It should be noted that the IAIR DS provides access not only to descriptions of decision support methods, but also to their implementations stored in the repository of the DS methods. This allows the user to directly test different methods, as well as gain access to their implementations, which can be used by him to create DSS and other applications.

Thus, this resource can be useful to the following types of users:

- developers of intelligent DSS (programmers, knowledge engineers and experts),
- decision-makers,
- researchers developing new methods of decision making,
- persons studying the knowledge area "Theory of decision-making".

### III. STRUCTURE OF ONTOLOGY OF IAIR DS

The ontology used in the IAIR DS, along with a description of various aspects of the modeled area of knowledge, contains a description of the structure and typology of information resources and methods for processing and analyzing information associated with this area. In this connection, the ontology of the IAIR DS consists of three interconnected ontologies responsible for the representation of the three components of knowledge above mentioned, namely: ontology of the knowledge area of IAIR DS, ontology of the tasks and methods of DS, ontology of scientific Internet resources.

Ontology the knowledge area of IAIR DS sets a system of concepts and relationships designed for a detailed description of the knowledge area of IAIR DS and scientific and research activities performed in this area.

The ontology of tasks and methods of DS describes the tasks to be solved in the knowledge area of IAIR DS, the methods of solving these tasks and their implementation. In particular, this ontology presents the connections of the decision-making stages with the tasks to be solved at these stages and the methods used for their solution, the connections of the DS methods with the software products (services) implementing them, the connections of such products with the persons and the organization which developed them, with publications

describing them and Internet resources providing access to them.

The ontology of scientific Internet resources serves to describe information resources presented in the Internet and relevant to knowledge area of the resource.

### IV. APPROACH TO DEVELOPMENT OF ONTOLOGY OF IAIR DS

The development of such a complex ontology as ontology of IAIR DS from scratch is not an easy task, therefore for its development methods and tools provided by the technology for creating thematic intellectual scientific Internet resources (ISIR) [2], proposed by the Institute of Informatics Systems, were used.

#### A. Method for Development of Ontology

The essence of the suggested method is to build an ontology based on a small but representative set of base ontologies including only the most general entities that do not depend on specific areas of knowledge. This set includes (see Fig. 1): the ontology of scientific knowledge, the ontology of scientific activity, the base ontology of tasks and methods, the base ontology of scientific information resources.

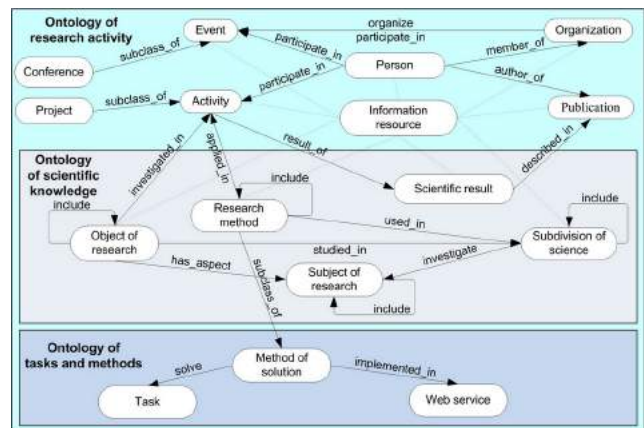


Figure 1. Base ontologies.

The ontology of scientific knowledge contains classes that define structures for describing concepts used in any scientific area of knowledge. Such concepts are the Division of Science, the Object of Research, the Subject of Research, the Method of Research, the Scientific Result, etc.

The ontology of scientific activity includes classes of concepts related to the organization of scientific and research activities, such as Person, Organization, Event, Scientific Activity, Project, Publication, etc.

The base ontology of scientific information resources includes the Information resource class as the main class. The set of attributes and connections of this class is based on the Dublin core standard [3]. To represent information about the resource sources and its co-hosts, as well as related events, organizations, persons, publications and other entities, special

relations are introduced that connect the Information resource class with the classes of other ontologies of the resource.

The base ontology of tasks and methods includes classes such as Task, Solution Method, and Web Service. Using the concepts and relations of a given ontology, we can describe tasks that can be solved in the knowledge area of the resource being created, methods for solving such tasks and web services implementing these methods.

In accordance with the proposed methods, the ontology of the knowledge area is constructed on the basis of the first two base ontologies, the ontology of the tasks and methods of the DS – on the basis of the third base ontology, the ontology of scientific Internet resources – on the basis of the fourth base ontology.

### B. Ontology Design Patterns Used in Design of IAIR DS Ontology

As said above, the IARP DS is developed using the technology for creating thematic intellectual scientific Internet resources [2]. The base ontologies provided by this technology are developed in OWL language [4]. The use of this language caused problems associated with the fact that the proposed concept of knowledge and data representation in the ISIR is not always convenient to fit into the capabilities of the OWL language. To solve these problems, as well as other problems arising in the development of ontologies, we use ontology design patterns.

Ontology design patterns (ODPs) [5], [6] have been used for more than ten years to streamline the development of ontology and reduce its laboriousness. ODPs are documented descriptions of proven solutions of problems of ontological modeling [7]. ODPs allow us to describe both typical and specific problems arising in the development of ontologies, as well as recommendations and agreements proposed by the developers for their solution. The main catalog of such patterns is presented on the portal of the Association for Ontology Design & Patterns (ODPA) created within the framework of the NeOn project [9].

Depending on the type of problems for solution of which the patterns are designed, there are several types of patterns: structural patterns, correspondence patterns, content patterns, logical inference patterns, presentation patterns and lexico-syntactic patterns [8], [9]. In this paper, we will focus only on those that were used in the development of ontologies for the IAIR DS, namely: structural logical patterns, content patterns and presentation patterns.

The need to use structural logical patterns arose due to the lack of expressive means in OWL for the presentation of complex entities and constructions that are relevant to the construction of the IAIR DS ontology. The technology of creation of thematic INIR offers structural patterns for representing such complex constructions necessary for the construction of ontologies, as domains (ranges) of admissible values, attributed and n-ary relations, relations between the object of one class and the class of other objects.

When creating the ontology of the knowledge area of the IAIR DS, it is important to unambiguously and consistently represent scientific concepts and their properties used in basic ontologies. To solve this problem, content patterns defining ways of representing typical ontology fragments are required. Ontologies of a whole class of subject domains can be built on the basis of such patterns.

When developing the ontology of the DS knowledge area, content patterns developed earlier for the implementation of projects for the creation of scientific Internet resources for a number of scientific subject areas are used. On the basis of such patterns, basic ontologies of scientific activity and scientific knowledge are built. These patterns, serving to represent objects and methods of research, performed activities, scientific results, etc. (see Fig. 2 and 3), are common for many scientific subject areas. Such patterns, in turn, can be part of more complex content patterns.

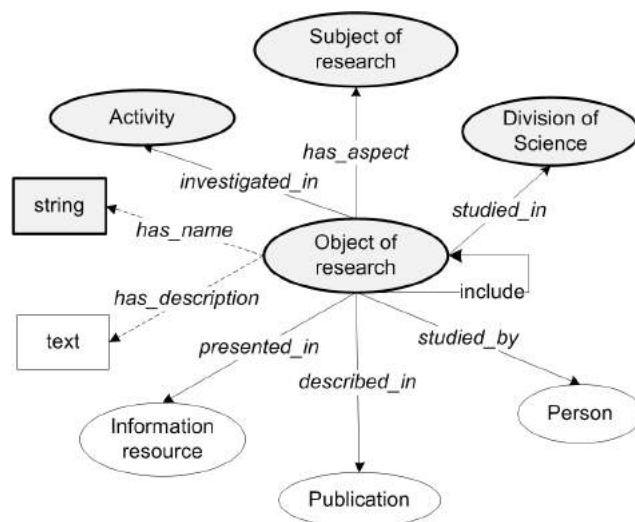


Figure 2. Object of research pattern.

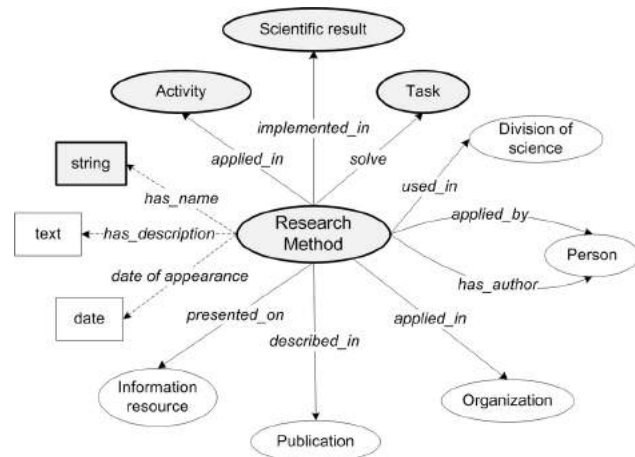


Figure 3. Method of research pattern.

It should be noted that the content patterns include not only the concepts presented by them, but also concepts from "adjacent" patterns, as well as patterns of other base ontologies, which allows you to specify a related description of the modeled area.

In fact, the content patterns are fragments of base ontologies that become constituent parts of the ontology of the modeled area of knowledge after supplementing with new concepts and specializing the concepts contained in them.

It is very important to provide a user-friendly and understandable ontology view. For these purposes, presentation patterns that define conventions for naming, annotating, and visualizing ontology elements for the end user are used.

The technology of thematic ISIR creation provides the possibility to customize the display of information objects (ontology class instances) included in the ISIR content when they are displayed on the monitor screen. For these purposes, it offers and implements the presentation pattern mechanism [2], which allows you to customize the visualization of objects of selected classes when they are displayed to users or editing.

#### V. CONCLUSION

The paper considers the approach to the development of an information-analytical Internet resource that supports the process of creating intelligent DSS in the weakly formalized areas. Its peculiarity is that the creation of this resource basically boils down to the development and populating of its ontology, which serves not only the purposes of formalizing and systematizing knowledge, data, processing and analysis tools that are integrated in the resource, but also used to organize user-friendly content access to them.

During the development of the IAIR DS, methods and components of the technology for creating thematic intellectual scientific Internet resources based on the ontological approach [2] and Semantic Web tools [10] were used.

It should be noted that the use of patterns of ontological design in the development of IAIR DS allowed to save resources in the development of ontologies and provide a consistent representation of all ontology entities, which in turn allowed minimizing the number of ontological modeling errors, increasing the clarity of ontology and provide the possibility of collective development of ontologies.

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### ОСОБЕННОСТИ РАЗРАБОТКИ ИНТЕРНЕТ-РЕСУРСА ДЛЯ ПОДДЕРЖКИ РАЗРАБОТЧИКОВ ИНТЕЛЛЕКТУАЛЬНЫХ СППР

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Рассматривается подход к разработке интернет-ресурса, обеспечивающего поддержку процесса создания интеллектуальных систем поддержки принятия решений в слабоформализованных областях. Данный ресурс представляет собой доступную через Интернет информационную систему, интегрирующую и систематизирующую знания и информационные ресурсы области знаний «Поддержка принятия решений в слабоформализованных областях» и разработанные в рамках этой области средства обработки и анализа информации, а также обеспечивающую содержательный эффективный доступ к ним. Для формализации и систематизации знаний, данных, средств обработки и анализа информации, интегрируемых в данном ресурсе, а также организации удобного содержательного доступа к ним используется онтология. В связи с этим создание данного ресурса в основном сводится к разработке и наполнению его онтологии.

В статье обсуждается методология разработки такой онтологии, которая включает методы построения целевой онтологии на основе представительного набора базовых онтологий (путем их специализации и дополнения новыми понятиями) и паттернов онтологического проектирования. Показано, что использование паттернов онтологического проектирования позволяет не только сэкономить ресурсы, затрачиваемые на разработку онтологии, но и обеспечить согласованное представление всех ее сущностей, что, в свою очередь, позволяет повысить «понимаемость» онтологии разработчиками и минимизировать число ошибок онтологического моделирования.