The Principle of Systems for Information and Analytical Activities Support Building Using OSTIS Technology

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***Abstract*—This paper describes principles of systems for information and analytical activities support building using OSTIS Technology. Also the main stages of the creation of such a systems as ostis-systems defined and described.**

***Keywords*—ostis, sc-code, semantic network, decision support system, knowledge base**

I. Introduction

The activities of any organization and its effective evolution are related to a purposeful and continuous analysis of the environment. The quality of management and the continuity of the system functioning depend on the quality of the information received (representativeness, content-richness, sufficiency, availability, relevance, timeliness, accuracy, reliability and stability).

The process associated with the search, collection (extraction), processing and presentation of information is usually called information-analytical activity [1]. The tasks of information and analytical activities in different subject domains may differ, but in whole they are similar:

- Collection of information;
- Processing of information in accordance with the goal;
- Transfer of information to the consumer (the person making the decision);
- Quality control of decision making.

The information systems used to solve this class of problems are Decision Support Systems (DSS).

Among the many possible criteria for DSS classifying [2], [3], [4], [5], the main ones are:

- by interaction with the user:
  - passive - a system that helps the decision-making process, but can not make a proposal, what decision to take;
  - active - directly involved in the right solution development;
  - cooperative - allows the user to modify, supplement or improve the solutions offered by the system.
- by the way of support:
  - model-oriented DSS, which use access to statistical, financial or other models;
  - DSS based on communications, which supports multi-user operation;
  - data-oriented DSS, have access to the organization's time series. In work they use not only internal, but also external data;
  - document-oriented DSS, which manipulates unstructured information, stored in various electronic formats;
  - knowledge-oriented DSS, which provide specialized fact-based solutions to problems.
- by technical level:
  - DSS of the whole organization - the system is connected to large information repositories and serves many managers of the organization;
  - desktop DSS, which is a system that serves only one user's computer.
- by functional filling [6]:
  - Execution Information System (EIS) - has a simplified interface, a basic set of proposed features, fixed forms of information representation;
  - The Desicion Support System (DSS) itself - is a full-featured data analysis and research system designed for trained users, having knowledge in the subject domain of the research.

In all the above variants of the classification, with the exception of the latter, one can trace the assumption of a continuous information exchange between the decision-maker person (DM) and the analyst, carrying out informational and analytical support of the decision. However, within a large organization, the head does not have the ability to carry out permanent monitoring of all information flows. This task is assigned to an analysts, and in this case it would be appropriate to talk about the system for information and analytical activities support (SIAAS), i.e. about the cooperative DSS system of the organization.

Thus, SIAAS operates in close interaction with an analyst (an expert in the field of knowledge). Accordingly, the results of such a system operation depend on the expert's knowledge. Undoubtedly, with this approach, new information should be created by the system without the use of "black box" models. This approach is especially justified in the formation of solutions in weakly formalized subject domains. Currently, such systems are created on the basis of subject domain ontologies, that is, are knowledge based [7]. As a rule, such systems are based on semantic networks and semantic technologies.

II. Problems of existing approaches

Despite the fact that there are approaches to the complex support of the intelligent DSS development process in the weakly formalized subject areas [8], a number of problems are traced in the works.

The first of them is the principle of ontologies creating. Ontologies can be created on the basis of semantic networks using the UML (Unified Modeling Language) [10], RDF (Resource Description Framework) [8] or conceptual maps [11] in a specialized editor only by knowledge base engineers, experts (analysts, users) are not able to do that. Ontologies are created manually, automatic (automated) integration of knowledge from heterogeneous sources is not considered. As a result, the knowledge base of DSS can act as a reference system or be used as a productions system for external programs. New knowledge can appear in the database as a result of knowledge-engineering or as the result of the work of production based programs. In some cases, simple factographic data received from external sources can be placed in the knowledge base [10].

The second problem is the principles of stored knowledge processing. As a rule, for each system, a specific implementation of the knowledge processing machine [12], which exists separately from the knowledge base, is developed. Such machine is a set of programs that interact with each other and the knowledge base directly, which implies a number of problems with the coordination of access to individual elements of the semantic network. In the OWL 2 format, it is possible to describe in the ontology so-called semantic reasoners, to test the ability of a class to contain some individuals, but most of them are capable of processing information only on the basis of direct logical inference.

The third problem is the principles of an interface building. Multiple editors of ontologies assume a universal interface. However, for a person who does not specialize in knowledge engineering, such an interface is not suitable. Moreover, different interfaces are needed to solve different tasks: one need a map to work with geographic information, and a formulas editor for mathematical problems. Thus, a unified knowledge representation does not always imply a unified interface.

And, finally, the process of intelligent DSS development based on semantic technologies is practically never described. It is completely incomprehensible how to parallelize the development of such systems: how to jointly develop the knowledge base and administer it, create knowledge processing agents, and protect information.

As a result of these shortcoming, at present there is no applicable technology to design intelligent systems for information and analytical activities support.

III. Proposed solution

As a technological basis to build a formalized system for information and analytical activities support, it is proposed to use Open Semantic Technology for Intelligent Systems (OSTIS).

OSTIS technology is aimed at development of computer systems, managed by the knowledge [13]. Computer systems of this class, developed by OSTIS Technology, are called ostis-systems. This is a complex technology that defines the theoretical basis for knowledge representation and processing, and contains a software implementation of semantic network storage (sc-storage) for Linux and Windows (64 bit). There are software adapters to working with sc-storage in C, C ++, Java, Python, .Net [14], [15]. The base code for knowledge representation in form of semantic networks with set-theory representation within the OSTIS is called SC-code (Semantic Computer code).

The OSTIS specification defines for any system a platform-independent unified logic-semantic model of this system (sc-model of a computer system) and a platform for such models interpreting. In turn, each sc-model of the computer system may contain a sc-model of the knowledge base, a sc-model of the knowledge base processing machine, an interface sc-model and an abstract sc-memory in which the SC-code constructions are stored. It is possible to describe semantic code constructs in both textual (SCs, Figure 5) and graphical (SCg, Figures 3 ,4) notation. In addition, there is a platform-independent graphical procedural language SCP (Semantic Code Programming), whose program texts are also written using SC-code.

Thus, using OSTIS as a technological platform, we will consider the principles of formalized system for information and analytical activity support design.

IV. Stages of an ostis-system for information and analytical activities support design

The design of the ostis-system for information and analytical activities support should start with the choice of the platform and the deployment of OSTIS [16] technology components. Then it is necessary to develop ontologies of top-level subject domains. To do this, it is enough to complement the sc-models core, which is the most important component of the reusable OSTIS components library, since it already contains ontologies of the most common subject domains, for example, the subject domain of numbers and numeric structures, the subject domain of sets, etc. At the same time, the intelligent metasystem IMS [17] provides consulting services and support for ostis-systems developers. It accumulates libraries of reusable OSTIS components. It is very important at this stage to ensure the IMS and the projected system's

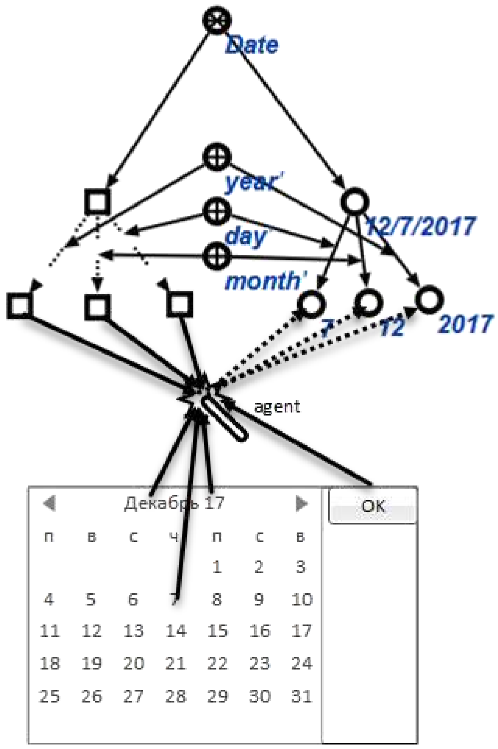

Figure 1. Agent-generated sc-construction based on template

compatibility at the level of entities and sc-models. You need to make sure that the new concept of a child ostis-system is correctly handled by IMS agents, does not contradict the already existing concepts in the knowledge base of IMS. For example, in Figure 3 one can see that the *time in transit in minutes** tag has a data type incompatible with IMS.

At the second stage, a system of subject domains and their ontologies are developed, in which a system for information and analytical activities support operates. First of all it is necessary to implement the ontology of classes of system tasks. As mentioned earlier, only knowledge engineers can create ontologies in the knowledge base. For users (analysts) this process is inaccessible, since it requires special knowledge and skills, as well as for security reasons. Also, there are difficulties with the integration of data from various sources.

To solve these problems, it is necessary to develop a so-called basic patterns of ontology models. Then on their basis, using agents, appropriate ontologies will be created. This approach became possible due to the presence of elements of a variable type in OSTIS. A schematic diagram of such agents operation using the example of the date generation agent is shown in Figure 1.

This approach makes it possible to create the so-called dynamic ontologies that the expert (the analyst) creates himself. At the same time, the creation of structures takes place through a user-friendly interface. So the user may not even suspect that he is working with the knowledge base, not with the regular program. The basic patterns of ontology models allow you to create the same constructions with different timestamps and for different users, which allows you to describe temporary data and solve security problems.

Thus, in ostis-systems, domain ontologies can be created by knowledge base engineers, by agent-adapters from external sources and by users themselves on the basis of patterns of ontology models using the familiar and user-friendly interface.

In parallel with the creation of domain ontologies and basic patterns of ontology models, it is necessary to create software agents for their processing. This can be done in any of the available programming languages for a particular implementation platform or using SCP as a unified cross-platform language for knowledge processing. Several developers can do this at the same time, in conditions that the ontologies and the base model templates are as independent as possible. It is also necessary to implement agents for the production of new knowledge. Thus agents can use any approach to knowledge processing. The core of the ostis-systems knowledge processing machines (sc-machines) already includes a minimal set of domain-independent information search sc-agents, necessary for the ostis-system knowledge base navigation.

The main problem in the software agents development is a performance. The SCP language is cross-platform, the agents, based on it, are part of the knowledge base. However, the execution of programs in this language can be inefficient in terms of performance compared to agents implemented in C++ or on the .Net platform. But the use of agents not implemented on SCP makes the ostis-system platform-dependent.

The third step is a system interface development. The intelligent OSTIS metasystem (IMS) already contains a basic user interface. Its main task is to translate the message from the user, received in some external language, to the internal language of the system (SC-code), and also translate the system response to some external language, understandable to the user and display this answer [18]. The graphical interface is based on the use of SCg-code (Semantic Code graphical), which is one of the possible ways of visual representation of SC-code texts. It is assumed that any ostis-system should use the technology of such interfaces design. However, this does not mean that the ostis-system for information and analysis activities support can not use its own interface designed for it, convenient for the end user and suitable for solving a certain class of tasks. Figure 2 shows the interface of the geo-information subsystem.

In this example, the interface displays text and graphic information about the route. The agent collects the data to display from the knowledge base. Route information is also available for viewing and editing via the unified IMS interface (Figures 3, 4). However, to work in such an interface, you need to know the SCg-code. Thus, it is advisable to use the unified interface for system developers and knowledge base engineers. For ordinary users (analysts) it is better to use a friendly interface developed for them.

Thus, the technology of ostis-systems design allows to create and use any necessary interface, not only unified. For, example some ostis-systems use a speech interface.

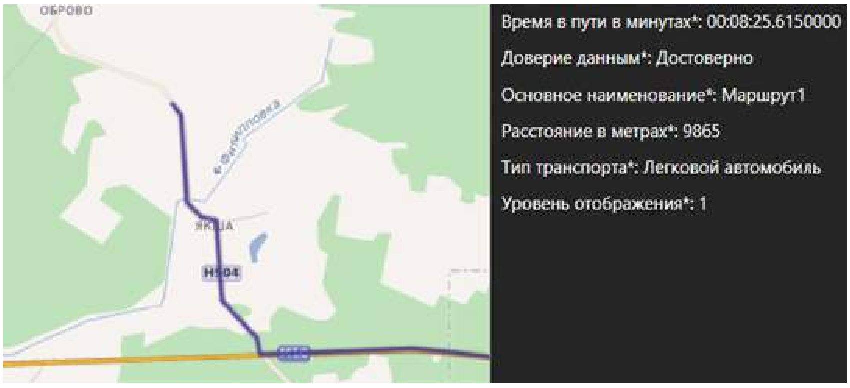

Figure 2. Information about the route in the GIS.

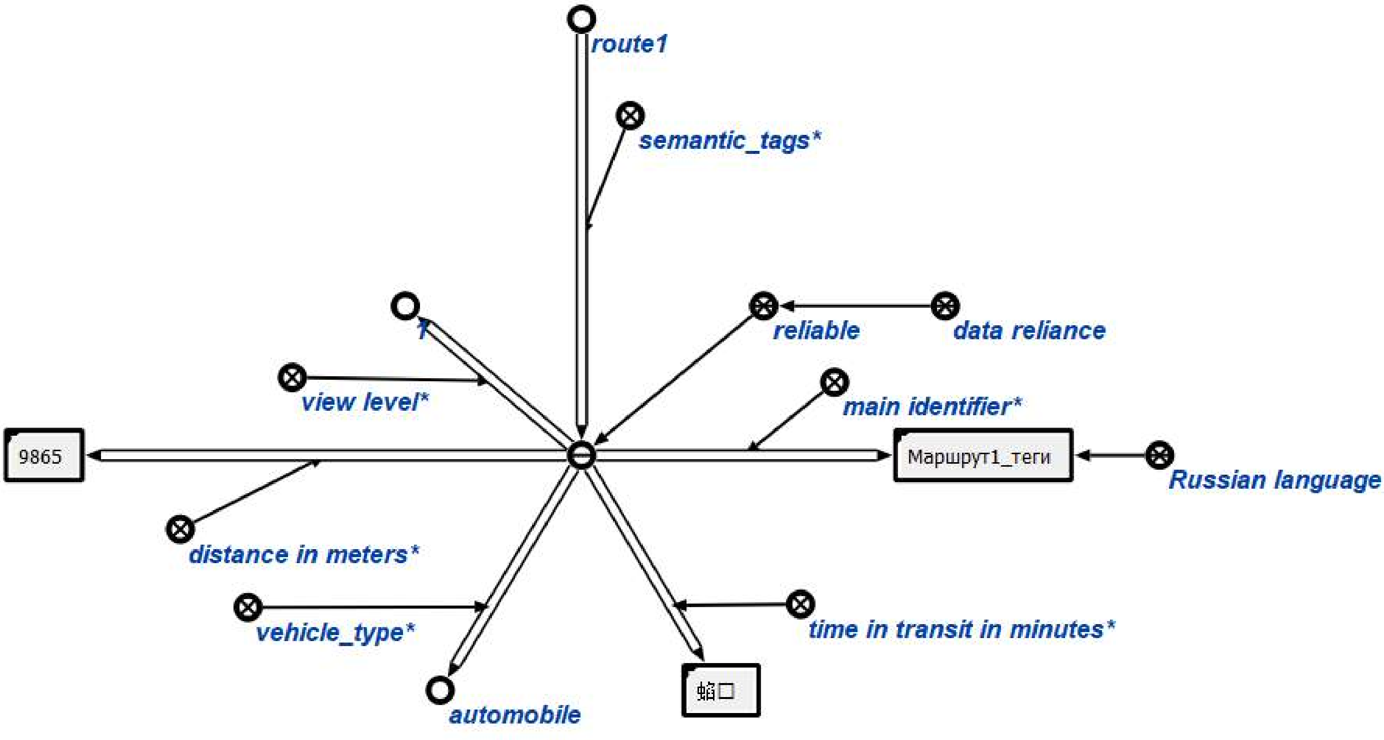

Figure 3. The route tags in knowledge base

The fourth stage is the integration of knowledge. It is necessary to develop appropriate ontologies of sources (recipients) of data, their models. It is also necessary to create adapter models. After the development of collection (data transfer) and information processing agents, it is necessary to take care of its verification. It is assumed that integration with external information sources means avoiding cross-platform. However, at present time due to several technical problems, in practice, any ostis-system with the developed domain-dependent interface already acquires dependence on the platform for which this interface is intended. Integration of information leads to the creation of a semantic network, where the entities from the various components are represented in the form of an interconnected graph.

To improve performance, you can organize the storage of individual elements of the knowledge base in specialized databases, and store only references to them in the knowledge base. So, for example, it is expedient to store video materials, indexes of geodata, indexes of full-text search.

ACKNOWLEDGMENT

To test the proposed principle of system design, we have developed a system for information and analytical activities support in the field of border management, based on the Common Integrated Risk Analysis Model (CIRAM) FRONTEX [20].

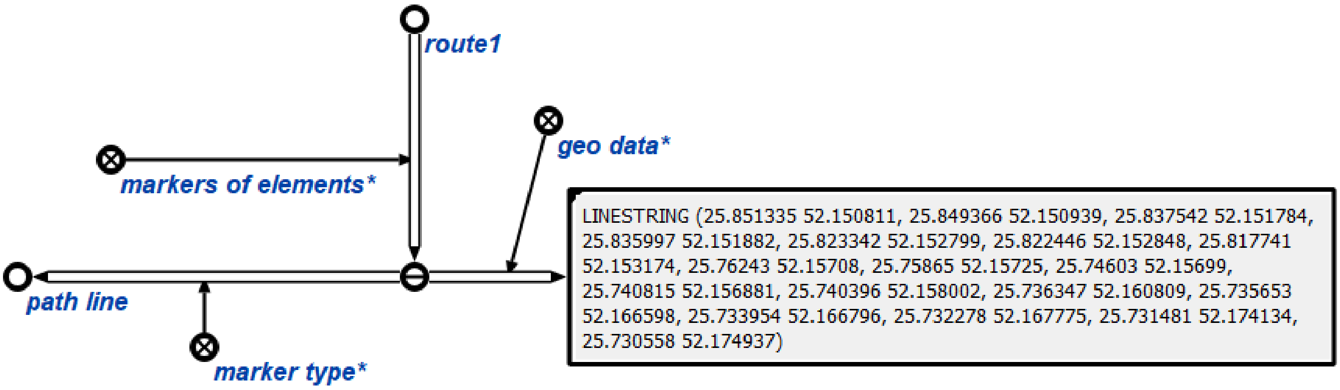

Figure 4. The route marker in knowledge base

```
class_sbs_vulnerability_route<-sc_node_not_relation;;
class_sbs_vulnerability_route => nrel_main_idtf:[Abstract route] (*  <- lang_ru;; *);;
class_sbs_vulnerability_route => nrel_service_description:[Abstract route for analisys]
(*  <- lang_ru;; *);;


_temp_sbs_vulnerability_route<-class_sbs_vulnerability_route;;

sc_node_not_binary_tuple ->_tuple_sbs_vulnerability_route;;
_temp_sbs_vulnerability_route _=>nrel_service_description_tags:_tuple_sbs_vulnerability_route
(*
 _=> nrel_main_idtf: _temp_link_ru;;
 _=> nrel_service_gis_zindex: _temp_service_gis_zindex;;
 _=> nrel_service_gis_vehicle_type: _temp_service_gis_vehicle_type;;
 _=> nrel_service_gis_route_time: _temp_link_time_interval;;
 _=> nrel_service_gis_distance: _temp_link_num_long;;
 _=> nrel_service_info_type: _temp_service_info_type;;
*);;
```

Figure 5. The route template in SCs code

The information system is designed to work in OS Windows 7-10, the platform-independent part is implemented on .Net. During the implementation of the first stage, a small expansion of the Sc-models core was required: several data types (TimeSpan) and an ontology for working with geoinformation content were added. At the second stage, the basic templates of ontology models of countries, vehicles, people, resources were developed. To fill the ontologies, the interface for working with map and other data is implemented. A platform-dependent agent for similar images search is developed. Some simple production inference agents have been implemented, for example, an agent of adding a car model to the models set of a car brand.

The ontology of weather conditions has been developed, software adapters are being developed to obtain weather information from third-party sites. Currently, the development of the system is at the 2nd - 3rd stage of design.

Developed ontologies and basic models templates are maximally independent, which allows to distribute the development among several employees. Thus, OSTIS Technology is an appropriate basis for the design of systems for information and analysis support.

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ПРИНЦИПЫ ПРОЕКТИРОВАНИЯ СИСТЕМ ПОДДЕРЖКИ ИНФОРМАЦИОННО-АНАЛИТИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ НА ОСНОВЕ ОТКРЫТОЙ СЕМАНТИЧЕСКОЙ ТЕХНОЛОГИИ ПРОЕКТИРОВАНИЯ ИНТЕЛЛЕКТУАЛЬНЫХ СИСТЕМ

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В настоящее время в информационно-аналитической деятельности широко используются информационные системы, относящиеся к классу систем поддержки принятия решений (СППР). Некоторые из таких систем основаны на базах знаний на основе семантических сетей. При этом, авторы считают, что системы поддержки принятия решений, основанные на знаниях и использующие опыт аналитика необходимо отнести к отдельному классу - систем поддержки информационно-аналитической деятельности.

Не смотря на то, что существуют подходы комплексной поддержки процесса разработки интеллектуальных СППР в слабо формализованных предметных областях, в настоящее время отсутствует технология создания таких систем. Авторами предложены принципы разработки таких систем с использованием технологии OSTIS. В статье определены этапы проектирования таких систем и содержание каждого из этатов. Рассмотрен подход к созданию т.н. динамической онтологии на основе шаблонов. Приводится пример платформозависимого интерфейса для работы с картографической информацией.

Для апробации предложенного принципа проектирования систем нами разработана система поддержки информационно-аналитической деятельности в области охраны границ, основанной на методологии CIRAM (Common Integrated Risk Analysis Model) FRONTEX.