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Semiotic-Agent-Ontological Approach To Design Intellectual Transport Systems

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ABSTRACT: *In paper is examined new approach to design of the intellectual control systems on the basis of agents-semiotics modeling and ontological bases of knowledges (on the example of automation of marshalling yards). The mathematical models of the automated processes and systems descriptions, principles of construction of simulations hybrid models and their co-operating with the intellectual bank of ontological bases of knowledges are considered.*

KEYWORDS: *Agent-Semiotic Modeling, Bank of Ontology's, Intelligent Control Systems, Marshalling Yards.*

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I. INTRODUCTION

The modern stage of development of information systems is characterized by the transition to the field of intelligent systems, which are characterized by the following features: - working with poorly structured, non-formalized data, which constitute up to 80% of all knowledge of mankind; - territorially and functionally distributed resources with a network-centric model of storing large amounts of data; - working in real time mode with strict restrictions on the time of decision-making; - the integration of systems based on WEB-technologies with the achievement of new quality due to synergy; - the systems being developed are transformed into a class of large, complex systems in which (according to Gelfand-Tsetlin [1]) the structure of the system is an essential parameter that affects their effectiveness; - the modern systems are multi-structural formations (Fig. 1); - noted features of the systems give rise to problems of incompleteness of data and uncertainties in the decision-making process, which led to the emergence of the concept of "gray analysis" and "gray systems", described by numerical and linguistic variables; - the implementation of an intelligent interface and working in "gray" conditions require the organization of knowledge bases and the construction of "hybrid systems of artificial intelligence" with the use of interrelated models of fuzzy sets, genetic algorithms and neural networks [2, 3, 4, 5, 6, 7, 8].

Within the framework of the funding of research and innovation programs "Horizon 2020" in the European Union, the project INTEND (INTEND (INtentify future Transport rEsearch NeeDs, GA 769638), is realizing, which contains an analysis of the future transport needs in scientific research. In section D 2.1 (ed. 0.4, 25.04.2018) the synopsis of perspective projects and technologies on transport is resulted [9]. In the field of railway transport, 68 projects are planned to be implemented, among which on the system level the corporate intelligent transport systems are paid attention. In [10] this is about the introduction of integrated traffic management systems. Advanced Traffic Management Systems (ATMS). Features of the architecture of intelligent systems of control are presented in [7].

The design and development of such systems is constrained by the problem of describing their types of support under the curse of dimensionality [11]. This is especially important in the process of conceptual design, which brings us back to the fundamentals of semiotics, which recently developed in new methodological approaches to the creation of intelligent systems [12, 13, 14]. In this paper, the architecture of the agent-semiotic approach is presented on the basis of the ontological knowledge base to the creation of intelligent transport systems by the example of automation of marshalling yards.

II. METHODOLOGY

The proposed approach to the analysis and conceptual design of intelligent control systems is based on the synergy of semiotics, agent technology, ontologies and simulation modeling of technological processes. Intellectual control system will be described in the form of nine sets

$$SM = \langle A, R_c, R_s, R_p, K_c, K_{cs}, K_{csp}, R_v, K_{cspv} \rangle \quad (1)$$

where

$$A = \{z_i\}_{i=1,N} \quad (2)$$

the set of basic atomic symbols (signs, terms, agents) used to construct syntactic constructions (3);

$$z_i = (\bar{a}_i; \tilde{a}_i) \quad (3)$$

complex atomic agent, consisting of static $\bar{a}_i$ and dynamic $\tilde{a}_i$ part;

$$(\forall i \in cj)(\bar{a}_i) \xrightarrow{R_c} K_{cj} \quad (4)$$

the set of syntactically correct constructions K_{cj}, built from static atomic symbols using the set of syntactic rules R_c;

$$(\forall i \in cj)(K_{cj}, \tilde{a}_i) \xrightarrow{R_s} K_{csm} \quad (5)$$

the set of semantically correct constructions K_{cspm}, obtained from syntactically correct constructions K_{cj} and the dynamic component of atomic agents $\tilde{a}_i$ using the set of rules for semantics R_s;

$$(\forall m) K_{csm} \xrightarrow{R_p} K_{cspm} \quad (6)$$

the set of pragmatically correct constructions K_{cspm}, built from semantically correct constructions K_{csm} using the set of rules of pragmatics R_p;

$$(\forall m) K_{cspm} \xrightarrow{R_v} K_{cspvm} \quad (7)$$

the set of new, deducible right constructions K_{cspvm} using the set of inference rules R_v.

The proposed agent-semiotic description of any system (Fig. 1) makes it possible to describe its multi-structural scheme and to determine all types of structures and their resource support in accordance with the concept of the information system architecture adopted in [11].

The proposed scheme is based on an intelligent data bank, which includes a hierarchy of knowledge bases: a database (DB), a knowledge (or rules) base (KB), and a goals base (GB), which in semiotics correspond to syntactics, semantics and pragmatics. The knowledge bank is implemented on the basis of ontologies - explicit specifications of conceptualization [15].

At the bottom level of the structure is the ontology-based knowledge base, which describes the technological macro level of the marshalling yard.

III. RESULT AND DISCUSSION

In Fig. 2 shows one of the components of the macro level - the marshalling hump. In turn, the "Marshalling hump" has such structural elements as "Humping movement", "Hump", "Slide" (elements of the class "Scheme of the marshalling hump"). The slide section includes: "High-speed section", "First braking position section", "Intermediate section", "Second braking position section", "Turnout zone section", "First section of the marshalling track", "Third braking position section", "Second section of the marshalling track".

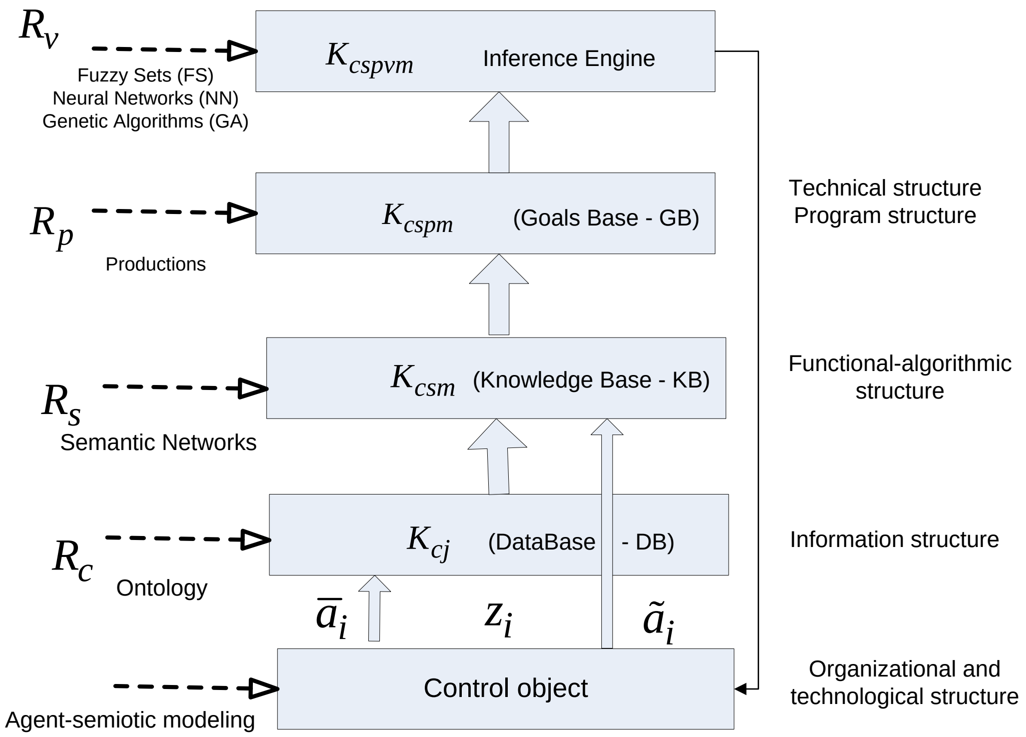

Figure 1. Multi-structure of intellectual management

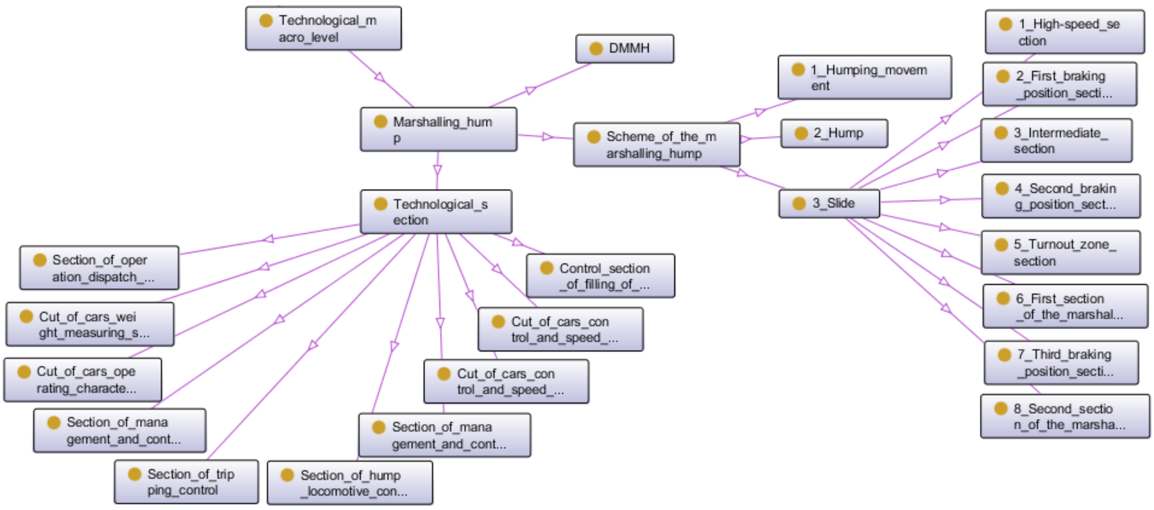

Figure 2. A generalized ontological model of a marshalling hump

Another important component of the knowledge base is the class "Technological section", which describes the different types of technological sections of marshalling hump. These include: "Section of hump locomotive control", "Section of tripping control", "Section of management and control of automatic turnout", "Section of management and control of non-automatic turnout", "Cut of cars weight measuring section", "Cut of cars operating characteristics measuring section", "Cut of cars control and speed regulation section at the interval braking position", "Cut of cars control and speed regulation section at the target braking position", "Control section of filling of tracks in marshalling park", "Section of operation dispatch equipment". Also on the taxonomy of concepts there is a class "DMMH", describing mechanization devices of the marshalling hump.

An important advantage of ontology is the fact that all its elements can be detailed. Thus, it is possible to enlarge the structure of the marshalling hump up to a specific technological section. For example, Fig. 3 shows a diagram of the hump locomotive control section.

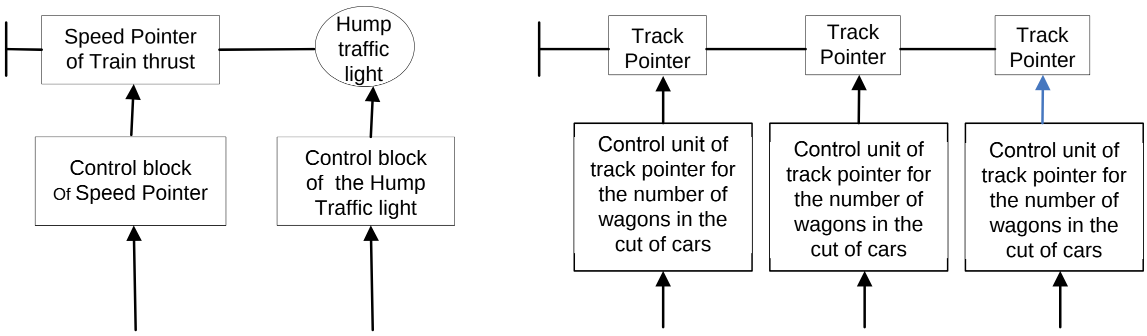

Figure 3. Locomotive control section on the marshalling hump

The detailing of the elements described in the ontological knowledge base can be of immense scales, but the principle of hierarchy and systematization of information is observed. The components of the structural parts and technological sections of the marshalling hump have different characteristics and properties. They can be quantitatively and qualitatively described using a variety of software tools for working with ontologies. For example, you can specify the exact number of technological sections of each type, or fully describe the technical and operational characteristics of the marshalling hump.

At the lower level of the system (Fig. 1), agent-semiotic modeling is used to form the set of basic agents (2), (3). The basis of the modeling is a hybrid discrete-event and agent simulation modeling [16]. The description fragment of the marshalling hump at the freight station using static agents is shown in Fig. 4.

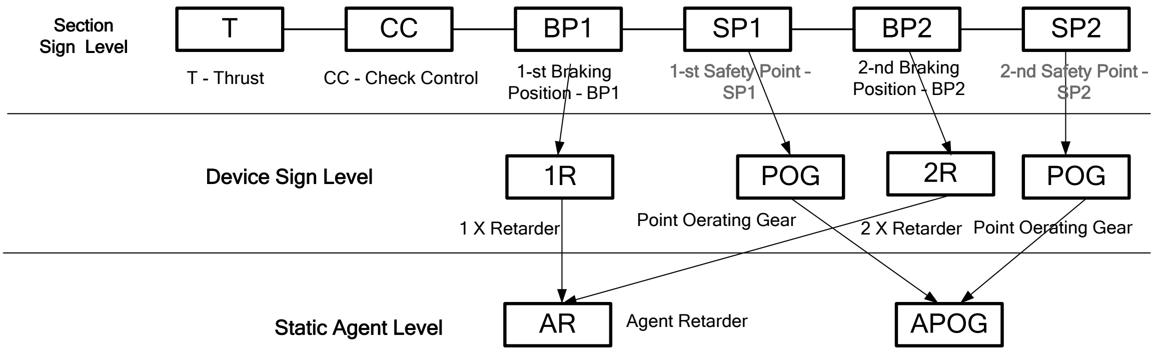

Figure 4. Fragment of the character description marshalling hump

During the development and use of ontology-based knowledge bases, a problem arose to support Cyrillic to describe ontologies in OWL-bases. To solve it, postgraduate student Loboda D. developed a special program, which was tested experimentally and showed its effectiveness.

The proposed agent-semiotic approach relies on the developed under the guidance of Professor Kosolapov A. method and automated system integrator complex - SIC [3] at the Computer Department of the Dnipro National University of Railway Transport (DIIT).

IV. CONCLUSSION

The features of the modern stage of the transition to intelligent control systems were considered and a method of their description in the form of nine sets $SM = \langle A, R_c, R_s, R_p, K_c, K_{cs}, K_{csp}, R_v, K_{cspv} \rangle$. On the basis of this model, a multi-structure of intelligent management is built, which is based on an intellectual knowledge bank. On the lower level, ontologies are used to describe the organizational and technological structures of control objects and their elements as agents consisting of a static and dynamic part. To create variants of structures, it is proposed to use hybrid agent-semiotic and discrete-event modeling.

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