

Intelligent Control of Micrologistical Systems for the Railway Transport Based on an Ontological Approach

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Abstract — This article deals with the interaction of the participants in the transportation process, the integration of heterogeneous data in the micrologistic systems of railway transport. The due attention is paid to the ontological approach to describe the structure, types of relationships of the transport system. It is proposed to use the transport system of classification in the construction of ontology. The OBDA approach for integration of heterogeneous data based on semantics is considered.

Keywords — *micrologistical systems, ontological approach, system of classification, intelligent control, digital railway*

I. INTRODUCTION

In a competitive market, there is a redistribution of resources between different types of transport, depending on the profits earned in accordance with the use of competitive advantages. Thus, for small and average distance operations, rail transport competes with road transport, and, in some cases, with river and marine transport (transportation of building materials, agricultural products, food and light industry products, etc.). At the same time, since 2011, the growth rate of freight turnover in road transport is higher compared to rail transport [1]. Oil cargo transportation is a sphere of competition with pipeline, marine and river transport. In the field of long-distance passenger operations, public transport competes with air transport, and in suburban and interregional operations - with road and, in some cases, with river transport.

One of the main strategic objectives confronting the railway is to increase its competitiveness by ensuring the quality of transport services based on providing for the safety and reliability of the transportation process [2]. It is impossible to sustain competitiveness and increase the attractiveness of transport and logistic services without the use of modern digital technologies. There is a sufficiently developed information and

computer network operating on the railways of Russia, which is the basis for providing high-quality transport services. Russian Railways OJSC launched the integrated scientific and technical project "Digital Railroad" under the state program of Digital Economy of the Russian Federation [3].

Today, achieving high economic results lies in the sphere of interaction between different types of transport and complementing each other, rather than competition between them. Supply chain management is a new direction of optimization and organization of well-minded freight traffic, which makes it possible to ensure high efficiency and minimize costs, while meeting high market requirements. However, different approaches are used for managing supply chains in individual logistics systems. The characteristics of these approaches depend on the type and level of the system. Usually, a logistic system is a complex organizational and technical system consisting of subsystems. There are micro-, meso- and macro level systems. First ones are considered as the object of research in this paper.

Let us introduce the definition of a micrologistical transport system (Micro LTS). This is an intra-production system of a transport enterprise, which consists of technically related functional divisions, united by a single infrastructure [4]. The interrelationships of the elements of this system are based on the intra-production relations. The influence of random factors is usually large in such systems [5], thus, queueing theory is applied to take them into account [6, 7].

With a great number of participants in the transportation process, data integration is of paramount importance. The lack of integrated approaches to organizing data collection, lack of coordination between system developers, "adjusting" reference and analytical material to the interests of end customers resulted in a situation where, in the presence of almost all operational

information of the traffic management process in automated systems of various levels, its use is significantly lower than its potential and, therefore, does not produce the desired effect. That is where an ontological approach may come into play. It will be discussed in more detail in the next section.

II. METHODS AND MATERIALS

The main idea of modern research is the transform unstructured network data sets into knowledge and to create tools and applications that work with it. Currently, developments in the field of intelligent systems are carried out in all spheres of activity, including railway transport, transport and logistics systems, including the works of the authors [8, 9]. Huge, constantly growing arrays of heterogeneous data, describing the diversity of many groups of objects, determine the need to develop a unified ideology based on the use of universal information systems, which not only allow solving inventory problems at a new technological level, but also offer fundamentally new opportunities for data analysis and synthesis.

Many integration problems are solved on the basis of an ontological approach. Major contribution to the development of ontologies was made by such foreign scientists as Gruber T. [10], Guarino N. [11], Lenat D. B., Guha R. V. [12], Noy N., McGuinness. D. [13]. Mention should also be made of the works of Russian scientists: Gavrilova T.A. [14], Khoroshevsky V.F., Skripkin S.K., Nikolaichuk O. A., Yurin A.Yu. [15,16] et al.

Ontology, as defined by Gruber [10], is a specification of conceptualization, a formalized representation of basic concepts and the connections between them. Conceptualization is an abstract, enlarged vision of the world that we want to present for some purpose; the transition from the description of the domain area in a natural language to the description by way of a formal specification.

Formally, ontology is a quartet of the form $\langle C, R, P, A \rangle$, where

C is a set of concepts of a specific domain area;

R is a set of relationships between concepts;

P is a set of attributes of concepts;

A is a set of axioms.

Ontology is a vocabulary shared in a knowledge management system to simplify communication, interaction, memorization and presentation of knowledge, and is a structure of hierarchically related semantic categories that allows self-description of the categories used in it through the relevant topics [17-19].

The process of creating ontologies is complex and controversial. Experts from different areas (programmers, experts, linguists) can be involved during the formation of ontologies, and each of them uses their own methods of work. The theory does not yet offer a universal method for developing

ontologies. In addition, the concept of their “correctness” can be defined only for each specific example, taking into account the purpose of the ontology and the general goals of development. The goal of ontological analysis is to identify the functional structure of the system (objects and their connections) and determine its behavior (scenarios) [20]. The result of this analysis is actually the development of ontology.

The IDEF5 standard [21] defines only a generalized (simplified) algorithm of actions. The insufficient depth of elaboration of information structuring methods, as well as the lack of a deep theoretical basis, put forward the task of searching for the fundamental bases to achieve the goal of creating a developed ontology of the transport industry.

For the initial study, let us consider the ontology of the transport and logistics system, whose basic concepts, interrelations and the classifications are presented in a non-formalized way in Figure 1. These classes are interconnected with various objects in a given subject area, each of which is similarly a subclass of the top level ontology.

However, the availability of systematized information in databases is not yet sufficient for effective management. When working with relational databases (widespread in railway transport), poorly reflecting the semantics of the domain area, there is a problem of integrating heterogeneous data. To provide effective solution of this problem, it is necessary to work with data corresponding to a certain semantically richer data model.

Ontologies, like systematic [8], are closely related and most enlarged models of the system under study, which make it possible to better understand it and formulate its essential properties. The most important stage of the model development process is to select the structure of the system that is of interest to us.

When building domain ontology of a micrologistical system (Fig. 2), let us turn to the taxonomy of a specific area of activity: the transport industry [8]. For systems consisting of a wide range of interconnected subsystems, it is first necessary to outline the main subsystems and establish the main relationships between them. Thus, in the taxonomy of the next level, **TRANSPORT** is divided into large taxa **Vehicles**, **Tracks**, **Micro LTS**, etc. The term “Vehicles” includes all devices for the transportation of goods and passengers. “Tracks” and “Micro LTS” contain transport amenities, such as land, water and air routes, pipelines, marine and river ports, railway stations and stations, airports, airfields, transport terminals, etc.

Within the scope of the OBDA (Ontology-Based Data Access) approach, architecture of the system of semantic data integration based on ontologies is proposed (Fig. 3). Ontology plays the part of a high-level conceptual framework providing a user interface. Thus, ontologies are an intermediary between the user with his information needs and the database system (Fig.4).

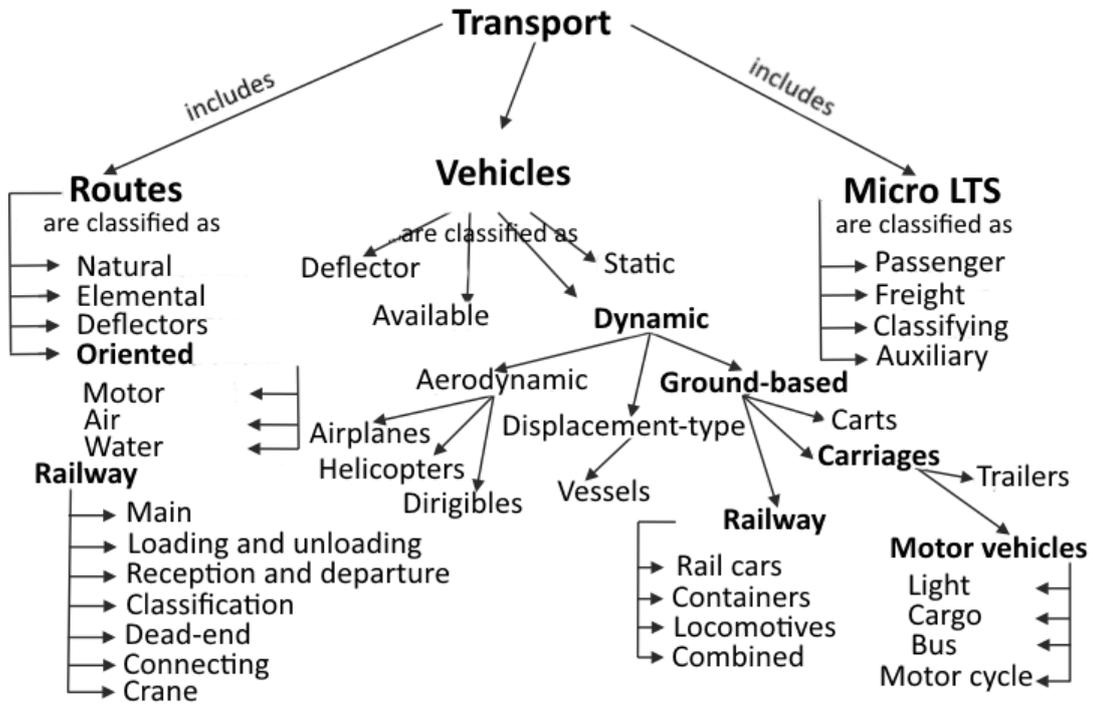


Fig 1 Ontology of the transport and logistic system.

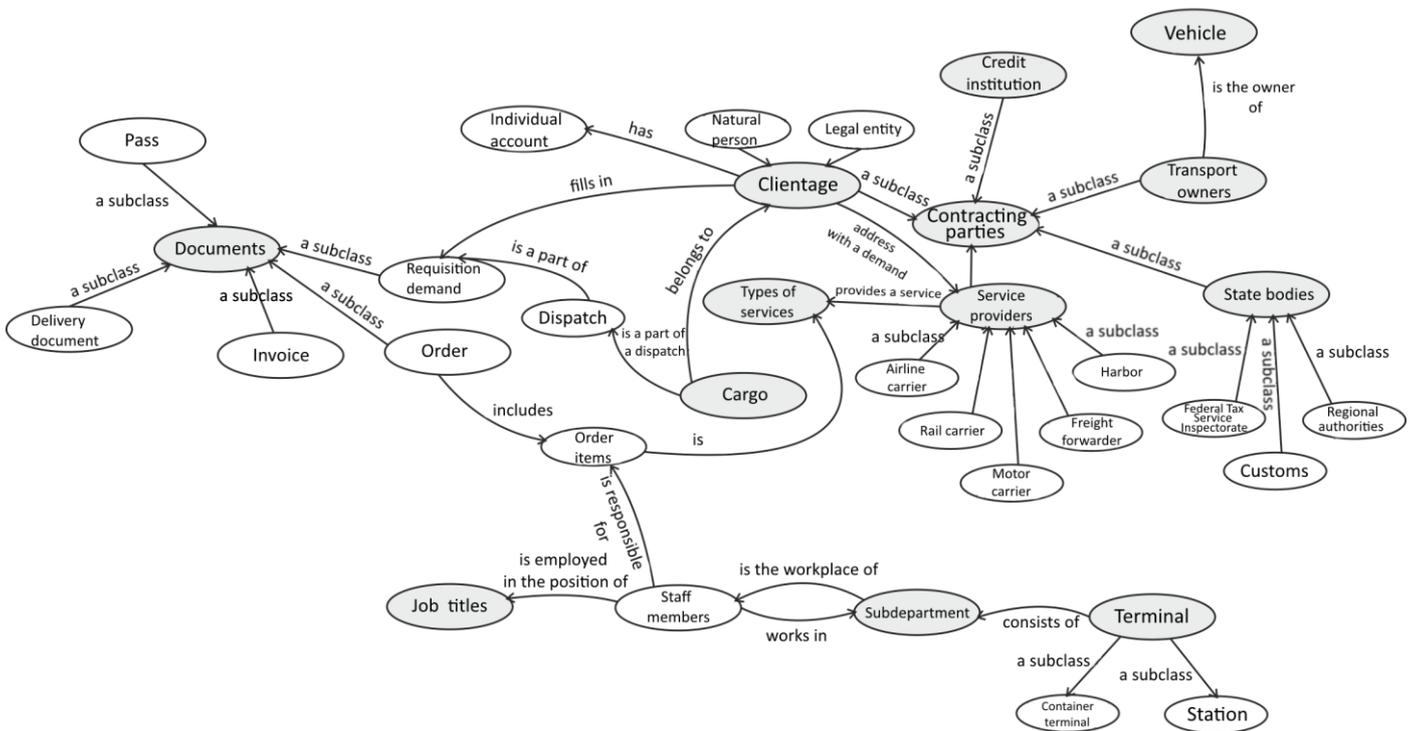


Fig 2 Rough ontological model of a micrologistical transport system.

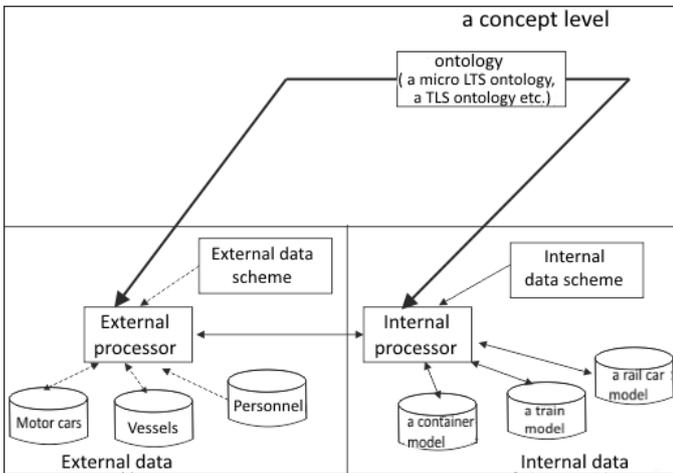


Fig 3 Architecture of the system of semantic data integration based on ontologies.

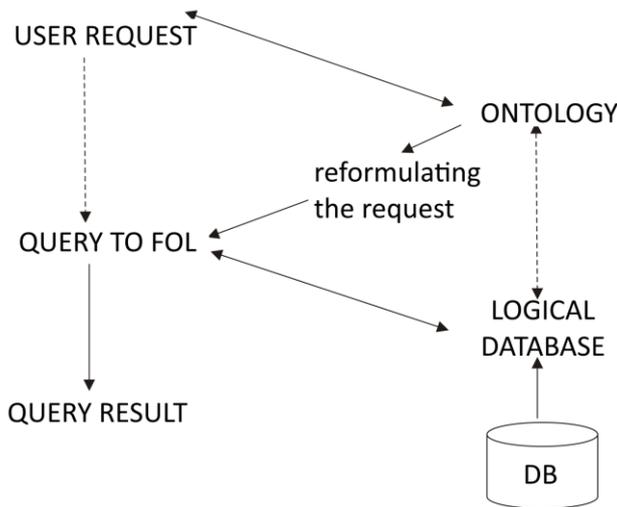


Fig 4 The scheme of receiving a response to a query when combining data based on ontologies.

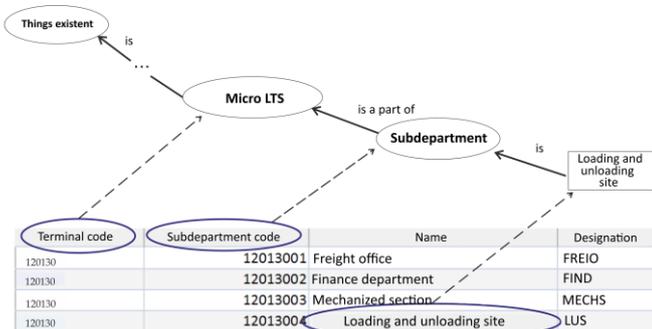


Fig 5 Linking concepts and data.

This kind of approach [22, 23] assumes the conversion of a set of tables of a specific database into a set of similar names with slots corresponding to columns of the respective table, and projecting the links between the tables into the relationships between them. The instances of ontology concepts are records

of tables, key values. Figure 5 schematically shows the linking of ontology concepts and table data. As a result, the ontology of the micrologistical system (Fig. 2), the ontology of the transport and logistics system (Fig.1) are used with access to the upper level ontology.

III. RESULTS

As part of the study, the following observations were made:

1. The ontological approach can be useful for integrating data and presenting knowledge in micrologistical systems of railway transport.

2. Due to lack of an explicit methodology for creating ontologies, the capabilities of taxonomy can be applied as an integrated domain area model.

3. Ontological domain area models are developed. The ontology of the transport and logistic system reflects the upper levels of the taxonomy of the basic concepts of the transport industry, structure, and types of relationships. The top ranks of the transport taxonomies are taken as a basis. The ontology of the micrologistical transport system specifies the ontology of the domain area in the frame of the task under consideration, shows in detail the interaction within the system.

4. The OBDA approach is considered as a scheme for the integration of heterogeneous data based on semantics, which connects ontology concepts and data from relational database tables. This approach takes advantage of descriptive logic for working with ontologies to retrieve queries to databases. As a result, queries to knowledge bases can be redirected as queries to databases. Considering that the transport and logistics information systems contain a large bulk of various data obtained from individual carriers, infrastructure owners, customers and other contractors, the issue of integration and data recognition remains relevant. It can be claimed that the technology of OBDA systems have reached the level of elaboration that justifies commercial implementation, and soon there will be publicly available software tools for their development.

IV. CONCLUSION

Summing up, it should be noted that, despite the high level of development of computer technology in OJSC Russian Railways, which makes it possible to use the latest information technologies, information interaction within transport and logistic systems remains insufficient. There is a need to develop a unified ideology based on generic information systems that allow one meeting the challenges of the new technological level of cooperation between the participants of transport and logistic sector, as well as providing fundamentally new possibilities for data analysis and synthesis of knowledge based on them. The problem of searching for scientific support for the fundamentals of modeling information systems based on ontologies, developing a fairly general methodology for structuring concepts and representing knowledge of the transport industry remains relevant.

The article proposes an approach to the construction of ontologies of micrologistical systems in railway transport, based on the taxonomy of transport [8]. Further studies in this direction may be related to the development of ontologies of

specific transport systems based on the proposed approach, followed by the creation of an intelligent transport system based on them.

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