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System Analysis and the Task of Ontological Modeling of Multimodal Transportation

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Abstract. The basic principles of synthesis and processing of information, laid down by Tim B. Lee and determined at the level of schemes, models, syntax and ontology dictionaries, have been further developed in the following study. Detailed study and formalization of specific areas of knowledge based on conceptual schemes in the basis of ontological engineering constitutes today the basis for the generation of modern knowledge and is the key to reducing the production of information debris. A comparative analysis of tools for constructing, comparing (analyzing) ontologies has shown the expediency of using the Protégé system. With the help of this tool, the authors implemented an instance of an ontological model of the domain of “multimodal transport” with a view to its subsequent application in the construction of appropriate multi-agent models.

1. Introduction

The vast majority of modern Internet users regularly use the services of search engines such as Yandex, Google, Rambler, Yahoo, etc. This practice has become a daily necessity. At the same time, the results of the processing of requests to these services are constantly deteriorating. An aggravating situation is determined by a number of qualitative and quantitative changes taking place today on the Internet.

The flow of unstructured information (documents, images, comments, notes, e-mails, video, audio, etc.) increases in an avalanche-like manner, the same can be applied to the influence of so-called “information violence” (pornography, information terrorism, fishing, etc.). The volume of information is constantly growing, which leads to the emergence of “information noise”, a state of person in which one ceases to distinguish the important information from info debris and begins to “consume everything at random” [1].

In addition, it is important to note the high proportion of outdated and inconsistent information being posted on the Internet. So, for example, if a user searches for academic information, then there is a problem of non-reinforcement of the received information with reliable sources (for example, up-to-date ones in a temporal context) [2].

2. Selecting the Technology of Work with Knowledge

One of the latest studies of the international research company International Data Corporation (IDC) showed following [3]:

- since the beginning of 2010 the volume of data has grown 50-fold (one of the main factors of this growth is the increase in the share of automatically generated data);
- volumes of information will be doubled every two years for the next 8 years;
- in 2013, the volume of potentially useful data amounted to only about 20% of the total volume of information circulating on the Internet;
- less than 13% of potentially useful data is effectively used (i.e. less than 3% of the total volume of information on the Internet).

This raises a permanent question related to problem of dealing with information pollution and the possible ways to change the situation described, or at least to influence the reduction in the production of information waste.

According to the authors of the paper, the following deserve special attention from the set of known discussed approaches [4]:

- increase of efficiency of processing of information debris;
- reduction in the volume of its production.

2.1. Increase of efficiency of processing of information debris

In practice, the first of these approaches is manifested today in the form of a specific technology - the technology of “big data” (Big Data). In this direction, the role of cloud computing continues to grow unceasingly [2]:

- the number of servers working with this technology around the world should increase by 10 times in the near future;
- the amount of data managed directly by corporate data centers should increase 14 times.

Working with large data is unlike ordinary business intelligence process, where a simple addition of known values brings a result: for example, the summation of data on paid accounts becomes the sales volume for the year. When working with big data, the result is obtained in the process of cleaning them by sequential modeling: first a hypothesis is put forward, a statistical, visual or semantic model is constructed, on the basis of which, the correctness of the hypothesis is checked and then the following is advanced. This process requires the researcher to either interpret visual values or compose interactive queries based on knowledge, or develop adaptive machine learning algorithms that can produce the desired result. And the lifetime of such an algorithm can be quite short [5].

The information cited clearly indicates a steady, widespread increase in the need for permanent investment (recourse costs) to directly support the Big Data technology.

The transition to this technology allows you to efficiently process huge amounts of non-structured data. However, Big Data technology in its essence does not ensure the utilization of information pollution, being extensive with respect to the data being processed: it is oriented towards avoiding the use of regulated internal data sources with structured information (intracorporate systems such as classifiers, ERP, CRM and etc.) to external, unstructured super-large amounts of data provided by social networks, web logs, unordered arrays of video recordings, text documents, machine code, etc. up to fragmentary information located “on the vast” Internet.

Summarizing the thoughts on improving the processing efficiency of information pollution on the basis of Big Data technology, “more and more funds are needed for digging in this detritus, they need to be allocated often and the more information debris, the better”. Making such a conclusion, authors in no way claim to belittle the role of developers in this field and the corresponding resulting economic effect from the direct application of Big Data technology.

2.2. Reduction in the volume of information debris production

The second approach is primarily focused on increasing the information culture of Internet users and in the context of policies aimed at the formation of digital economy and digitalization of education

[6, 7], according to the authors it is the most relevant application. The basic ideas for reducing the volume of information debris production were laid by Tim B. Lee in the well-known article "Semantics of the Web" and are defined at the level of RDF schemas, models and syntax, and ontology dictionaries [8]. In other words, detailed study and formalization of specific areas of knowledge based on conceptual schemes in the basis of ontological engineering [9, 10] form the basis of knowledge generation and is the key to reducing the production of information debris.

One of the main advantages of practical use of ontologies is the possibility of integrating heterogeneous information. At the same time, the ontology defines the structure of the knowledge base, providing access to its contents, provides a dictionary for describing the concepts and acts as a common scheme for the integration of various databases. As a result, if there is a need for access to knowledge in the form of an ontology, it is not required to search through several different sources. Now, having received the required solution at the conceptual level, the next logical step is to detail the set of relevant tools, both for developing ontologies, and for comparing the results obtained, and also to determine with tasks oriented to the subsequent effective use of the knowledge generated in this way.

3. Analysis of Tools

With respect to tools for the development of ontologies, we will analyze a number of well-known software tools of a special profile value (Figure 1).

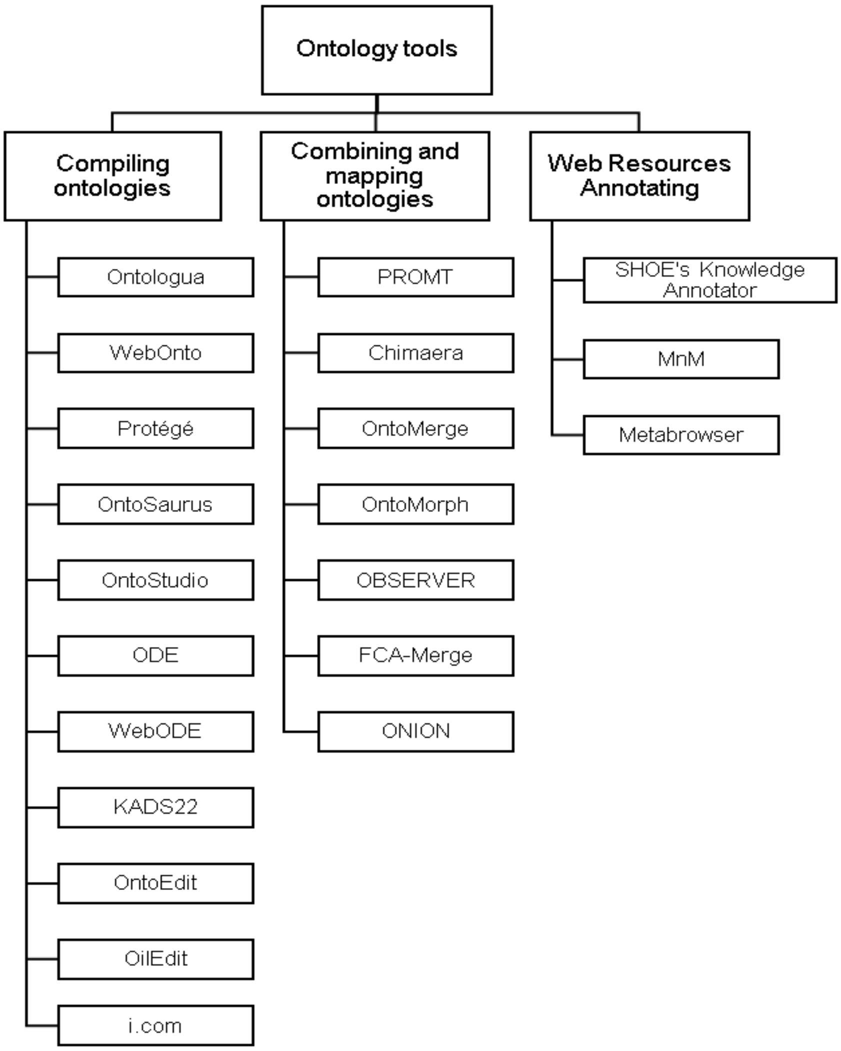

Figure 1. Classification graph of tools for working with ontologies.

Most of the known tools for building, mapping, aligning, combining ontologies are open or provide free access to their capabilities. The most complete and in-depth review-analysis of tools is given in [11].

OntoEdit, WebODE and KADS22 tools support Ontology, On-To-Knowledge, METHONTOLOGY and CommonKADS methodologies, which does not prevent them from being used in other methodologies or without them. Concerning the software architecture (local, client-server, n-tier), extensibility, programming languages on which tools are implemented, ways of storing ontologies (in files or databases), it is necessary to note the following. Earlier tools such as Ontolingua, OntoSaurus and WebOnto have a client-server architecture. Protégé, OntoEdit and OilEd have a 3-tier architecture, where there is a clear separation between the storage of ontologies, business logic modules of application logic and user interface applications. These tools have great extension capacity (for example, using plug-ins). Most tools store their ontologies in text files, which limits the size of ontologies. Only Protégé and WebODE can store their ontologies in databases and thus manage large ontologies. Finally, most tools are implemented in Java.

The variety of tools for mapping, aligning and combining ontologies makes it difficult to directly compare them. In fact, when a developer has to decide which tool is most suitable, everything will depend on the specific task.

Based on the above analysis and the practical experience of constructing ontologies, there is reason to argue that Protégé [12], a local/online editor developed at Stanford University, is the tool most common and adapted to the requirements of specialists in many subject areas, including logistics multimodal transport. Protégé includes an ontology editor that allows you to design ontologies in the form of a hierarchical structure of abstract or specific classes and slots, similar to a hierarchical directory structure. Based on the generated ontology, Protégé can generate forms of obtaining knowledge for introducing instances of classes and subclasses. The tool has a graphical interface convenient for use by inexperienced users, is equipped with references and examples. Protégé is based on the knowledge model OKBC (Open Knowledge Base Connectivity) [13] and is equipped with a number of plug-ins [14], which allow it to adapt for editing models in different formats (standard text, JDBC, UML, XML, XOL, SHOE, RDF and RDFS, DAML + OIL, OWL).

4. Development of Ontological Model

Variants of the subsequent application of the generated knowledge are numerous [15, 16]. Against this backdrop, the authors proposed the idea of forming an ontological model for the subject area "Multimodal transport of goods" (MMG) [17]. At the moment there is a number of information services for the effective use of passenger multimodal transports [18]. At the same time, modern global trends are aimed at improving the efficiency of the MMG [19]. It is also important to note that one of the most promising approaches for solving such problems today is the use of multi-agent models [20]. The latter, in turn, are based on using ontologies to provide communication between agents. In this way, the development of the ontology of the MMPG is an urgent task.

Multimodal transportations are carried out successively by several types of transport through a single transportation document. In this case, as a rule, there is a need for transshipment specialized premises from one type of transport to another in, temporary storage warehouses (TSW) or terminals [21]. For multimodal transportation, it is necessary to create or have an information base that allows planning, managing and controlling the whole process of cargo delivery from the consignor to the consignee with the assist of information support for the technological process of cargo delivery. As already mentioned above, the introduction of new forms of information support is an important aspect, including the functioning of a multimodal transport system as a whole, since it is precisely the proper and precise organization of such a system that determines its effectiveness.

The organizer and controller of the interaction of all links of the transport and logistics chain in the international transportation system is a multimodal operator (freight forwarder), which can also carry out the delivery of the goods by own transport and (or) attracting individual carriers [22]. The pace of development and expansion of the sphere of information is very high now. A certain feature of most processes, including transport, is the constant expansion and creation of new information links that are being improved and acquire new functions through the use of modern technology and technology.

The effectiveness of the system depends on the effectiveness of management of technological, organizational and other processes. In the management and implementation of the technological process of mixed transportation, the multimodal operator uses information retrieval systems, decision support systems, expert systems and others that ensure the efficiency of transportation. It is the use of information systems and knowledge bases that, due to the possibility of quick access to information about subjects (the buyer, the carrier, the terminal) and the objects (goods, services) of delivery, make it more effective. Hence, one can draw a conclusion about the importance and necessity of ensuring the continuity of controlled processes in the passage of goods and the accompanying information between networks of various transport operators. This is especially important in the implementation of uninterrupted multimodal transport (road / rail, rail/sea transport, etc.).

In this regard, in this paper, the authors propose a pilot version of the ontological model of multimodal transport of goods. To form the model, the Protégé editor used earlier was used [23]. The main class in the model is “Multimodal transportation”. Next, the subclasses “Consignor”, “Freight forwarder”, “Carrier”, which are included in the class “Multimodal transportation”, as shown in Figure 2 (highlighted area 1) are used.

In addition to the “basic” subclasses, the class “Multimodal transportation” includes a sub-class “Forwarder” in Figure 2 (Region 2) (the person who will be engaged in the organization and implementation of transportation). The freight forwarder is also associated with all persons (subclasses) who participate in the transportation, which is shown in the form of links (lines with arrows) in Figure 2.

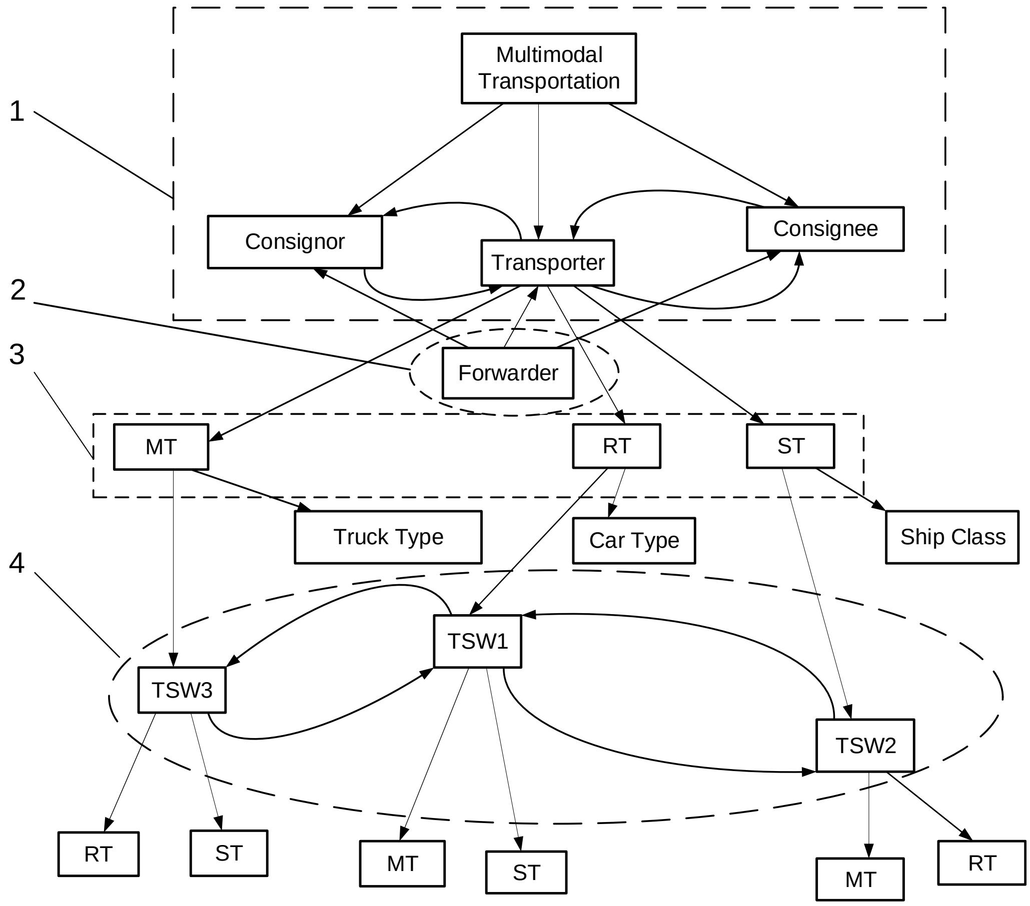

Figure 2. Graphical representation of the multimodal transportation model.

To carry out the delivery, the carrier chosen according to certain parameters suggests the type of transport on which the delivery will be affected. For this, we add additional subclasses of the second level to the subclass “Carrier” with the names of the modes of transport in Figure 2 (area 3). In practice, the type of transport (MT - motor transport, RT - railroad transport, ST - sea transport) directly depends on the carrier, which the shipper or forwarder chose. After choosing the transport, loading and unloading methods, transport routes, the vehicle is sent to the loading point, the necessary cargo is loaded, the vehicle driver receives the necessary documents and the transport should be sent to the next point of transshipment or unloading. These points are usually called temporary storage warehouses (TSW). There can be several TSWs at once, as it shown in Figure 2 (area 4).

Each mode of transport has the opportunity to come to this place and carry out transshipment or unloading of cargo. After that, the cargo remains in storage for TSW for a certain period, until the next transport arrives, to continue the delivery of the goods. Temporary storage warehouses are located in different locations: at the railway freight stations, in seaports, logistics terminals, where there is the possibility of approaching for other modes of transport. After reloading to another transport facility, the cargo should be furthered to the destination, to the consignee at the warehouse or to a predetermined place. However, if the route is complex and involves the use of rail, sea and (or) air transport, then for the delivery of the goods to the customer to the warehouse, “to the door”, the shortest route is taken. Motor transport is used in case the enterprise does not have its own driveways, or is not at the sea or river port. In this case, another cargo transshipment takes place on the road transport, and a follow-up to the final destination at the TSW.

To reflect all technological nuances of multimodal transport in an ontological model, slots are used - attributes of the class and properties of objects (for example, “Truck Type”, “Car Type”, “Ship Class”, as shown in Figure 2).

If the TSW can handle only a certain type of transport and (or) the cargo, then the object is assigned the appropriate properties.

Further within the framework of the model, to determine the significance of objects that participate in transportation, delivery of all types of cargo, in transport-forwarding activities, we will perform analysis of the relationships between objects and levels in the transshipment process.

Since the delivery of goods is carried out on different types of transport, different rolling stock, the methods of handling, loading and unloading, for different cases, are always different, as well as there are different conditions for the organization of transportation, therefore, the development of freight, cargo, transport, requires knowledge in this area and time for organization. Often to organize the delivery of goods, the consignor and the consignee use the services of a third-party firm, an intermediary, that is, a freight forwarder. The forwarder, as noted above, assumes the responsibility for the organization of delivery, which implies the choice of the carrier, the type or modes of transport, the organization of loading and unloading the cargo, the preparation of the necessary documents, and other processes. In Figure 2, some types of transport are shown (basic: MT, RT and ST), which can be offered and used in transportation. This list is extensible.

When choosing transport for transportation, it is more appropriate to use the type of transport that is able to deliver cargo faster than others, but such transportation will be more expensive. If it is necessary to deliver a large consignment of oversized cargo, which is not possible with road transport, then the sea transport is used. Transportation to long distances is much cheaper, using rail or inland waterways, if there are, of course, rail or waterways. Therefore, always for the organization of transportation, it is necessary to work out the whole route, know the terms of delivery and the wishes of customers, in order to determine the optimal delivery option.

Working in the Protégé editor, choosing the carrier, the mode of transport in the ontological model can be implemented using queries. To create a query, you must select a specific class and its slot (if necessary, you can select more than one class and more than one slot). It is possible to save created queries in a special library for reuse.

When carrying out multimodal transportation, it is often necessary to use a temporary storage facility for transshipment from one type of transport to another. This is due to the fact that not always both types of transport used can be at the same time in one place, or the load itself takes a long time. As shown in Figure 2 each type of transport interacts with the TSW, after which the distribution and reloading of the cargo to another transport takes place. After the cargo is loaded onto the last mode of transport used in transportation, it is delivered to the consignee in a warehouse or in a pre-specified place. There is also a transfer of documents for cargo, on the basis of which the consignee pays for transportation, registration, transshipment and delivery of cargo.

5. Conclusions

The proposed ontological model is based on modern presentation and legislation regulating transport conditions and fully complies with the practice of performing multimodal transport of goods in Russia.

As one of the tasks for further research, it is planned to use the developed ontology for modeling the processes of organization of multimodal transport of specific cargoes and to search for appropriate optimal solutions [24] within the framework of the work of the logistics lab of the transshipment complexes of the Platov South-Russian State Polytechnic University (NPI).

6. References

[1] The official website of the developer of the software product Protégé Avalaible: protege.stanford.edu
[2] Becker M and Smith S F 1997 An ontology for multimodal transportation planning and scheduling *Technical Report* CMU-R I-TR-98-15
[3] Chaudhri V K 1998 OKBC: A programmatic foundation for knowledge base interoperability *AAAI / IAAI* pp 600–607
[4] Berners-Lee T, Hendler J and Lassila O 2001 The Semantic Web *SciAm* vol 284(5) pp 34–43
[5] Nielsen J 2004 Ten Steps for Cleaning Up Information Pollution *Jakob Nielson's AlertBox* Avalaible: www.useit.com/alertbox/20040105.html
[6] Nunan, D and Di Domenico M 2013 Market research & the ethics of big data *Int. J. Market Res.* vol 55(4) pp 505-520
[7] Zelenko A P, Piankova V V and Teterina E V 2014 Information pollution: the problem of the XXI century *Actual problems of aviation and astronautics* vol 10 pp 240–241
[8] Chausova T 2013 Growth in the volume of information – the realities of the digital universe *Technologies and communications* vol 1 p 24
[9] Order of the Government of the Russian Federation of 28.07.2017 № 1632-r *On the approval of the program Digital Economy of the Russian Federation* Avalaible: government.consultant.ru
[10] Keshelava A V Budanov V G and Rumyantsev V Yu 2017 Introduction to the Digital Economy *VNIIGeosistem* p 28
[11] Mokhov V A and Silnyagin N N 2011 Integrated algorithm of cognitive evaluation and choice of the optimal variant of the ontological model *Eng. Bull. Don J.* vol 18(4) pp 351–356
[12] Mokhov V A 2015 *System analysis and ontological engineering* (Novocherkassk: Platov South-Russian State Polytechnic University (NPI)) pp 82–84
[13] Ovdei O M and Proskudina G Yu 2004 *A survey of ontology engineering tools* (Pushchino: RCDL2004) vol 7(4) pp 1–16
[14] Musen M A 1998 Domain ontologies in software engineering: use of Protege with the EON architecture *Methods of Information in Medicine-Methodik der Information in der Medizin* vol 37(4) pp 540–550
[15] Noy N F 2001 Creating semantic web contents with protege-2000 *IEEE intelligent systems* vol 16(2) pp 60–71
[16] Gavrilova T A and Leshcheva I A 2016 Conceptual structures of knowledge and cognitive style *Psychology* vol 13(1) pp 154–176
[17] Gavrilova T A, Lescheva I A and Leshchev D V 2000 Usage of ontologies as didactic means *Artificial Intelligence* vol 3 pp 34–39.
[18] Mokhov V A 2016 *System analysis of approaches to the modeling of technological processes*

(Novocherkassk: Platov South-Russian State Polytechnic University (NPI)) pp 92–93
[19] Serdyukov S D and Serdyukova N K 2016 Development of the ontological model of the tourist business subject area *Naukovedenie* vol 8(3) pp 1–20
[20] Lopatkin R Yu, Petrov S A, Ignatenko S N and Ivashchenko V A 2015 *Prospects for applying simulation modeling in problems of automation and control of technological systems* (Khar'kov: News of NTU KhPI) vol 17(1189) pp 61–71
[21] Avdeev D 2015 Multimodal transportation: definition, types, scheme *Internet-edition of SYL.ru* Avalaible: www.syl.ru/article/212195/new_multimodalnaya-perevozka-opredelenie-vidyi-shema
[22] Pluzhnikov K I and Chuntomova Yu A 2012 *Transport forwarding, agency service and broker-rage* (Moscow: TransLith) p 576
[23] Mokhov V A 2017 Analysis of the similarity of the formulation of some problems of discrete optimization (Novocherkassk: Platov South-Russian State Polytechnic University (NPI)) pp 110–112
[24] Tal A 2008 How to get out of information debris *Single World* Avalaible: kabmir.com/obshhestvo/kak_vylezti_iz_informacionnogo_musora.html