Запропоновано нову парадигму формування середовища інформаційно-аналітичної діяльності в адміністративному управлінні на основі онтологій. Показано, що застосування цього підходу дозволяє здійснити формалізацію предметної області та структурування інформації, необхідної для аналітичної діяльності. Встановлено, що застосування онтологічних описів у технологічному ланцюгу аналітичної діяльності забезпечує динамічне формування для аналітика відповідних множин критеріїв на основі використання властивостей концептів предметних областей, за якими здійснюється прийняття відповідних рішень. Зазначається, що процес розв'язання аналітичної задачі може уявляти певну послідовність упорядкованих тавтологій, кожна з яких наслідує усі властивості концептів, які складають тавтологію, що їй безпосередньо передує. У свою чергу ця послідовність визначає множину можливих таксономій як функціональних компонентів операційного середовища інформаційно-аналітичної діяльності. Для підтримки роботи аналітика пропонується застосовування ієрархії онтологій від верхнього рівня до предметних онтологій, включаючи проміжний рівень ядра онтологій. Ядро онтологій розширюється шляхом онтологічного зв'язування класів онтології з такими інформаційними ресурсами, як класифікатори. Коректність та адекватність такого рішення підтверджена застосуванням цієї парадигми до вирішення проблеми адміністративного моніторингу соціально-економічного розвитку регіонів країни від державного рівня до місцевого самоврядування

Ключові слова: інформаційно-аналітична система, орган управління, адміністративне управління, інформаційні ресурси, онтології, таксономія, класифікатор

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PATTERNS IN FORMING THE ONTOLOGY-BASED ENVIRONMENT OF INFORMATION-ANALYTICAL ACTIVITY IN ADMINISTRATIVE MANAGEMENT

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1. Introduction

Under current conditions, informational-analytical activity (IAD) in the administrative management bodies, in particular, at the state level, is becoming increasingly widespread. On the one hand, the IAD promotes the support of making effective administrative decisions, the socio-economic significance of which is constantly growing. On the other hand, the widespread use of information technologies makes it possible to create powerful information and analytical systems (IAS), which, along with receipt, conversion, and storage of information, ensure its analysis and analytical processing.

The main technology of analytical activity is the establishment of cause and effect relationships between different kinds of data and their research from various viewpoints. That is why the most important condition for successful analytical work of an expert in the management body is the availability of the information field of the studied domain area (DA). Under the conditions of using the IAS, this field can be the set of structured and unstructured information arrays (information resources) required for mining necessary data from them, and the IAS facilities provides for the possibility of an analyst to control the data processing and analysis. The construction of cause and effect chains makes it possible to turn the processed data into information and new knowledge and to synthesize the relevant guidelines for the customer of analytics (for example, the authorities of the management body) [1].

The informational and analytical activity, in particular, for decision making support, is usually implemented based on the use of certain hierarchies, reflecting the properties of information processes and resources [2–5]. The effectiveness of information resources, validity, and impartiality of prepared analytical recommendations in a certain way depend on the optimal determining and formation of these hierarchies. At the same time, it should be noted that the specified technologies have not been properly applied in the sphere of administrative management. This is one of the main reasons for insufficient level of decision quality, which eventually leads to negative social and economic consequences of their implementation.

The development of scientific research and experiences in the field of modeling the informational-analytical activity shows that one of the tools that can ensure the reflection of the interaction of all information components and effectively help to design and implement the mechanisms of management of the component hierarchy is an ontological model [3, 4]. The ontological model in its information basis has a mechanism of dynamic formation and the use of hierarchies in the form of specific taxonomies [5]. This approach to solving the problem of analytical activity support originates from the natural ability of people to determine events and logically establish relationships between them. A person is characterized by two features of analytical thinking – the ability to observe and analyze observations and the ability to establish relationships between observations. Assessing the level of interconnections between the relations, it is then possible to synthesize these relations into overall perception of the observable. The use of ontological descriptions in this technological chain provides for the dynamic formation for an analyst of the respective sets of criteria based on the use of the properties of concepts of domain area, by which the corresponding decisions are made. Thus, correctness and adequacy of the decision itself largely depends on correctness and adequacy of the ontology model of the DA.

At the same time, the problem of using ontologies in the field of analytical support of administrative management remains insufficiently resolved. The foregoing indicates the relevance of conducting research in the specified direction.

2. Literature review and problem statement

In the world, there are many studies on the creation and use of computer ontologies, the sources of which date back to the 1990s. It is reasonable to consider the studies dealing with the use of ontologies for description of the organizational structure of institutions, the relations between roles and agents, and powers among the components of organization as the basis of this direction. The organization (ORG) ontology was developed and standardized within the working group W3C, related to government data, and became a complete international recommendation. This contributed to the wide range of implementations of using organizational ontologies, for instance in the publications of organograms by the UK Cabinet Office.

The use of organizational ontologies as a source of structured knowledge about the specialization of an organization and its employees is proposed in study [6]. In this case, the thesauruses, formed for a domain area and for employees (experts) are considered as a separate case of ontologies. It is clear that such a structure reflects in a certain way relationships, characteristics and parameters of the managerial nature. However, the glossary-based approach, proposed in this paper, does not take into consideration the peculiarities of the administrative system of the state level. This leads to the fact that some objective difficulties arise at the attempt to use it to support the management of similar structures. This imposes some restrictions on the use of the solutions proposed in [6]. The description of such restrictions can be found, for example, in paper [7] devoted to the concepts of organizational modeling and ontological engineering.

Further development of the views on organizational modeling shows that a set of formalized models of a domain area and the ontology engineering methods can be the theoretical basis for modeling the architecture of the informational-analytical system of an organization (an enterprise).

Using an example of the development of the ontology of production resources, paper [8] proposed a general formal model that takes into consideration functional capacities and resource constraints and provided detailed information on the content and the structure of the model. It is noted that formal engineering ontologies become popular solutions for resolving the problem of semantic compatibility in heterogeneous environments, since ontologies play a key role, providing a general machine-clear dictionary for information exchange between separated entities. The emphasis on the paradigm of "production as a service", which has been adopted by many researchers, who developed different approaches to the formal description of service requests and offers, is interesting. One of these approaches is creation of a formal ontology of a domain area to provide the capacities of production services.

An example of the ontological description of information services can be a basic ontological model for the management of the products lifecycle, presented in research [9]. Industry needs solutions for interoperability between non-uniform systems, which can take into consideration the necessary semantics in order to establish uninterrupted unambiguous exchange of data information throughout the whole life cycle of products. The study proposes, as one of the most promising approach to solving these problems, the use of ontologies that serve as an inter-lingual language between the local data structures.

Determining the basics of the ontological description of the architecture of information and knowledge organization in a large corporation has become essential [10–14]. In study [10], the corporation was analyzed in two dimensions: descriptive and normative. The descriptive part is based on the principles of formal top-level ontologies; the normative part is solved through so-called social ontology. The relevance of this analysis is based on the need for better understanding of an organization, its structure and activities. In research [12], a semantic viewpoint regarding human resources management (HRM) in a corporation is modeled, specifically, an approach to checking the consistency of the constructed ontology is proposed.

In paper [13], it is determined how to overcome significant barriers that prevent the wider use of ontologies in the technique. The major obstacle among them is the lack of a common top-level ontology for the unification and organization of various aspects of the information field and coordination of the joint development of orthogonal ontology. As a result, many engineering ontologies are limited to the scope of their application, which functionally does not make it possible to expand them or to interact with other engineering ontologies. This study demonstrates how the use of top-level ontology (TLO), including the basic formal ontology (BFO), greatly facilitates the interaction of several engineering ontologies.

An ontological approach to supporting the supply contract by monitoring the loss of the contract's effectiveness because of the off-contract factors is proposed in paper [14]. The approach consists of ontological models and data-oriented algorithms. Ontology-based models not only formally represent the concept and relationship between the concepts involved in predicting the contract effectiveness, but also organize the use of additional data. These include news, reports on market indicators, industry databases containing information about the factors influencing the fluctuations in off-contract parameters.

Thus, systematization of the results of the above-mentioned research makes it possible to consider that existing approaches to solving the problem of information structuring, which occur mainly in production sphere, rely on formal ontologies. This conclusion can be also true for administrative (organizational) management. After all, there are not many publications about the use of ontologies in this area. Obviously, such approaches make it possible to find acceptable decisions only in the case if the state of the domain area is clearly known with the given degree of accuracy, and its mathematical description should be presented in the form of the determined sets of concepts and their properties. This part of the problem for the sphere of administrative management can be solved by developing the procedure for formalization of the domain area and information structuring based on the ontological model.

3. The aim and objectives of the study

The aim of this research is to study the features of application of the ontological model to form the environment of informational-analytical activity in administrative management.

To achieve the aim, the following tasks were set:

– to explore the peculiarities of using the ontological model in the environment of informational-analytical activity of administrative management bodies, based on the mathematical models describing the domain area of management;

– to develop the methodology for solving informational-analytical problems in administrative management based on the ontological model;

– to propose a scheme for practical implementation of the obtained solutions based on the typical informational-analytical problems in the structure of the IAS of the administrative management body.

4. Studying the issue of applying an ontological model in the informational-analytical activity in administrative management

The activity in administrative management is aimed at achieving certain goals by solving the set tasks. Administrative management bodies realize their own powers by performing a set of managerial functions from goal setting to making managerial decisions, as well as organizing and controlling the results of their implementation.

There are three types of administrative and managerial work – heuristic, informational and administrative (Fig. 1), which to a different extent belong to mental work.

The analytical activity related to goal setting, analysis of situations, searching for solutions to problems is most creative by character. In fact, it aims to develop a draft decision and prepare for its adoption. Operational work involves performing stereotyped operations required primarily for information support of the analytical process. It usually includes operations of documentation, information processing, computational and formal logical calculations. These two activities combined constitute the part of managerial work that belongs to informational-analytical work and is usually provided by information technologies.

The most characteristic features of administrative control are the activity under conditions of uncertainty and risk, high dynamics of the parameters of external environment, existence of global (general systemic) and local aims, which change in the process of activity and discreetness of managerial decision-making. In this case, domain areas of management are usually characterized by large dimensionality, structure complexity and the construction hierarchy, territory distribution, complexity of interaction of the elements and functional subsystems, which are generally determined by a large number of parameters (indicators).

That is why the specific feature of analytical activity in administrative management, unlike many other areas of management, is a much higher level of unstructured data that should be processed. In addition, a huge number of data sources prevail. As a result, in order to support the activity of an analyst, besides the use of data systems, it is necessary to provide knowledge representation.

Given the specified nature of the informational-analytical activity in administrative management, the systems of its support should include the facilities that ensure processing certain judgments, affirmations and statements regarding the DAA that carry the idea about the objects of domain areas, describe specific processes and can be represented by certain information models [15]. Such models should reflect a certain totality of knowledge that outlines the properties of considered objects and processes, with the possibility of automated reasoning and processing of semantic queries. The complexity of displaying and perception by an expert-analyst of properties and functionality of components and processes affects the quality of the prepared solution. Display of the processes and objects of the DA based on the model of a certain type requires joint processing of diverse information, which requires its interrelation, integration and ensuring interaction with other systems that are different by purpose.

It follows from the above that the representation of information models in the IAA environment in the form of a certain set of ontologies is considered the most adequate [16–18]. Each ontology is known to rely on the information description of the domain based on the object-oriented formalization procedure. It implies determining certain concepts and relations, as well as descriptions of the interpretational functions that on the basis of ontology govern the process of providing the information resource at all stages of the analyst's activity. Then some ontology O on the general case is formally represented by the orderly three:

$$O=(X,R,F), \quad (1)$$

where X is the set of concepts; R is the set of relations between concepts; F is the set of interpretation functions.

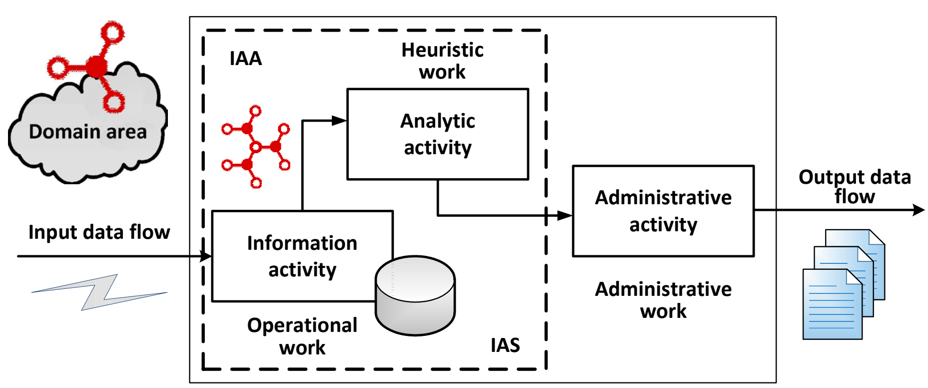

Fig. 1. The place of informational-analytical activity in administrative management

The concepts form finite set $X=\{x_1,x_2,...,x_i,...,x_n\}$, and set of relations R is formed by the set of Cartesian products $\boldsymbol{X}$ by itself: $R\subseteq X\times X$. It is possible to consider that relation R is the interpretation of the properties of concepts, that is, there is a transformation, which establishes correspondence of certain property to each relation.

The interpretation functions F, which is the way of meaningful interpretation of any formal system, form the functional part of the IAA.

It should also be noted that all non-empty Cartesian products of sets X and R form a certain subset of tautologies $F_k\subset F$. It follows that it is possible to assign a certain set of statements on set F. Thus, it becomes apparent that any ontology can be formed based on a particular system of statements.

Ontologies typically include the attributes of concepts, in particular, if it goes about the objects of the DA. An attribute is used to store data that are specific to an object and are related to it. Each attribute has at least the name and the meaning. An important role of attributes is to determine dependences (relationships) between concepts.

The ontology model should also include axioms, which are introduced to determine constraints to values of attributes of concepts and arguments of relations, to verify correctness of information, etc.

In practice, we use the expanded definition of an ontological system $O^{\Sigma}=O^{meta},\{O^{da}\}$, where O^{meta} is the meta-ontology, or top-level ontology, O^{da} is the domain area oriented ontology. In meta-ontologies, the universal concepts and relations concerning the general direction of analytical activity in this administrative organ are used. These meta-ontologies are oriented towards the creation of models of domain areas in the form of "world models" – completed, interrelated and inter-conditioned by knowledge systems. Certain concepts and relations, specific to the given DA, are used in subject-oriented ontologies. That is, the terminology base of the DA ontology is formed by specifying the concepts determined in meta-ontologies.

Consideration of boundary cases of sets X, R and F (X=Ø, X≠Ø, R=Ø, R≠Ø, F=Ø, F≠Ø) in the combination of their values gives different variants of ontological constructions, beginning from simple dictionary and taxonomy to the formal structure of the conceptual knowledge base for highly intelligent knowledge-oriented systems (so-called active ontology).

The taxonomy category as a category of ontological order is determined when X≠Ø, R≠Ø, F=Ø. By taxonomy, we imply a certain set of ontology concepts, which have a binary property "successive", which can be interpreted as follows: to be the following, to be current, to be the closest. Then taxonomy can be created by a certain non-empty set of relations of orderliness R_t, where $R_t\subset R\,|\,R_t\neq\varnothing$,

$$R_t=\begin{Bmatrix} t_1,t_2,...,t_i,...,t_n \left| t_i=\langle x_k\times x_m\rangle \right| x\in X, \\ k\neq m, k\leq n, m\leq n \end{Bmatrix}, \tag{2}$$

where t_n is the tautologies that are created by properties of concepts; x_k, x_m are the concept that form orderly relations. In this case, set $\{x_k\times x_m\}$ has the associative property [4, 19].

Thus, in the context of application of ontology sets in the IAA processes, it is possible to consider taxonomy to be a certain set of ontology concepts, which always have a binary non-commutative relation, which can be interpreted as the property to be the element of a specific class. It is also possible to form from these ontologies an orderly set, the elements of which also have a binary non-commutative property to be an element of certain ontology.

So, all concepts create a set of specific classes by their properties. All the statements that can be formed from the concepts that create a class based on a certain specific property should be tautologies [4].

5. Problem-oriented methodology for solving informational-analytical problems based on an ontological model

The main category, which belongs to analytical transformation of information with the view to providing for the process {action – result}, is the concept of a problem. Solving a certain set of problems with a totality of the set goals is provided by any IAS. The concept of the problem implies the existence of a problem situation and can be represented as tuple T [18, 19]:

$$T\equiv\langle K,K^*,Aim\rangle, \tag{3}$$

where K is the model of the DA, which displays the problem situation in terms of a certain ontology; K^* is the tuple of the DA states, which are implemented at each step of attaining goals, $K^*\equiv\langle K_0,K_1,...,K_i,...,K_n\rangle$; $Aim\equiv F\times R$ are the set of goals.

Then the problem-solving process may present a certain sequence of ordered tautologies, each of which inherits all the properties of the concepts that make up the tautology that directly precedes it. In the introduced formalization, this process can be represented in the following form:

$$T\equiv\langle K,K^*,F\times R,X,R_t,F,A,(X\times R_t\times R_s,R^+\times R_t)\rangle, \tag{4}$$

where A is the set of axioms; R_s is the set of constraints; $R_s\equiv R^+\times R$; R_s can be considered as finishing of relations R_t; R^+ is the set of properties that can characterize the elements of the set of taxonomies R_t.

Then the set of the states of solving problem T can be considered as a sequence of orderly tautologies, which determine the set of possible taxonomies as functional components of the informational-analytical activity. Thus, the themes of the IAS problems that supports this activity can be formed by a certain set of tautologies, which originate based on the classes constructed by the hierarchical structure of objects-concepts.

The DA structure usually has some set of properties, which do not follow directly from the properties of the components of its objects-concepts, but rather are the result of interaction of the elements based of realized relations. These properties are known as systemic properties (integral or emergent). If the management goal is set, the display of this goal on a set of properties separates some subset $Aim\subset R^+$. It is this subset of properties that enables the management system to determine the decision as for the influence on the DA system in accordance with the purpose of management.

The problem-solving process begins with the stage of conceptual analysis of the DA. If this analysis, for example, is related to the socio-economic state of the DA, the display is performed at this stage:

$$S_M \times \mathbb{R} \times C \times S_C \xrightarrow{E_{(n)}} S_1, \tag{5}$$

$$S_1 \times \Im \times S_C \xrightarrow{E_{(n)}} E_X, \tag{6}$$

$$Aim \times \Pi \xrightarrow{E_{(n)}} Q, \tag{7}$$

where S_1 is the set of strategies to achieve the aim; *Aim* is the set of aims that are achieved during strategy selection; Π is the set of socio-economic indicators that are used to assess the state of the DA; *Q* is the set of criteria; $\mathbb{R}$ is the subset of resources to achieve the aims that are separated from the general set of available resources; S_C is the set of possible scenarios of behavior of the DA environment; S_M is the meta-strategies of the DA behavior; $\Im$ is the set of the DA interests in the environment; *C* is the set of indicators that display the possibilities of DA activity in the environment; $E_{(n)}$ indicates that the display is formed as a result of agreed opinion of experts-analysts.

The complexity of analytical problems leads to the fact that their solution is carried out as a multi-step process. At each step, an estimation expert procedure of the choice of alternatives Q^* is performed, which corresponds to the generalized problem of decision making on the set of criteria *Q* and can be displayed as:

$$Q^* = \tilde{\Psi}_A \Rightarrow Q(\tau, \rho, \beta, \Re, \mathbb{C}, \mathbb{Z}), \tag{8}$$

where τ is the time of the life cycle of a problem issue; ρ is the risk distribution by life cycle stages; β is the resources distribution by life cycle stages; $Q^* = \tilde{\Psi}_A \Rightarrow Q(\tau, \rho, \beta, \Re, \mathbb{C}, \mathbb{Z})$ is the general volume of the resources allocated to solve a problem issue; $\mathbb{C}$ is the scenarios of behavior of the DA subjects, related to a problem issue; $\mathbb{Z}$ is the tuple of additional parameters; $\tilde{\Psi}_A$ corresponds to the choice of a compromise solution from the set of alternatives.

The obtained generalized theoretical-multiple models of achievement of management goals make it possible to conduct the analysis of tasks on condition of generality of description due to the use of abstract, the least limited data structures. These models are a fairly versatile methodological tool, which enables us to consider the operation of the DA elements and of the system as a whole in the operation process from a uniform position.

But to use such models, it is still necessary to solve the problem of representation of the data that correspond to the significant number of parameters used in the models. It requires a hierarchical structure of a finite set of concepts that describe the assigned domain area. As it was noted, these requirements correspond to the computer ontology of the domain area.

The diversity of the data required for the analysis of the domain area requires the use of a series of subject ontologies that detail the various aspects of DA functioning. But there are barriers that hinder the active deployment of such ontologies in administrative management. The lack of the common top-level ontology for the unification and organization of various aspects of the information field and coordination of the joint development of an orthogonal ontology are crucial among them. As a result, subject ontologies are limited in their volume, it is functionally difficult to expand or to ensure the interaction with other similar ontologies. On the other hand, a highly integrated character of ontologies eventually offers pronounced opportunities for the support of analytical activity.

The joint development of subject ontologies using a TLO as a top model means that the integration process involves the import of an ontology into a certain environment to allow them to interact with each other. For this purpose, it is advisable to use the general ontological core as a medium level between the TLO and other specific DA ontologies (Fig. 2). The general core is actually a set of ontologies, which offers a high level of terminology resource to support the use of corresponding ontologies. The core can contain a set of templates that can be used to expand and formulate new ontologies. Template repetition allows simpler formation of semantic queries, because the data displayed in ontologies is used by common super-properties [20].

The ontology of the general core can also be extended by ontological linking of ontology classes to such information resources as classifiers that usually exist in all IAS. Classifiers take a special place in information provision, as they provide a unified data representation. Using classifiers, it is possible to describe separate domain areas because they contain a set of useful structured information about the DA objects. This is especially important to ensure the stages of the conceptual analysis of the DA and the expert procedure described in expressions (5) to (8).

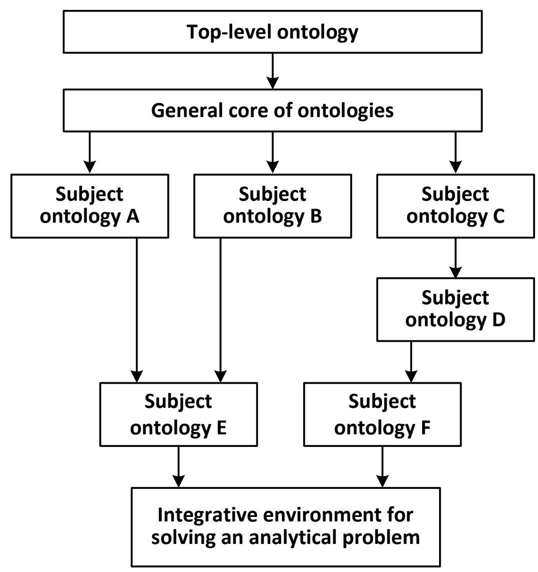

Fig. 2. Hierarchy of ontologies for ensuring the domain area analysis

Based on tautologies as representatives of classes, which are formed by ontology concepts, a new classification system can be created. Such a system, like any other system, should represent a certain hierarchy. Each of its elements, in turn, has the internal structure (elements of internal structure and their relations) and is linked to the external environment.

If interpreted by a classification language, the internal structure is grouping of the objects of classification, the relations of internal structure is the mutual relation between the groupings of classification objects, and the relation to the external environment is the interconnections between different classification groupings. In the interrelations of groupings, there are two aspects – structural and lexical-semantic. The former means the entry of objects to the classification based on binary relations and properties. The latter is the formation of certain sets of assertions-statements, which are tautologies in relation to the solved problems.

Then the task of creating a classification system is reduced to combining classifications at the specified two levels. When interacting with homogeneous classifications, the original classification often expands. This usually happens by adding new sections, sub-sections, as well as new indicators in the form of tautologies. New codes are assigned to these indicators according to the accepted encoding system.

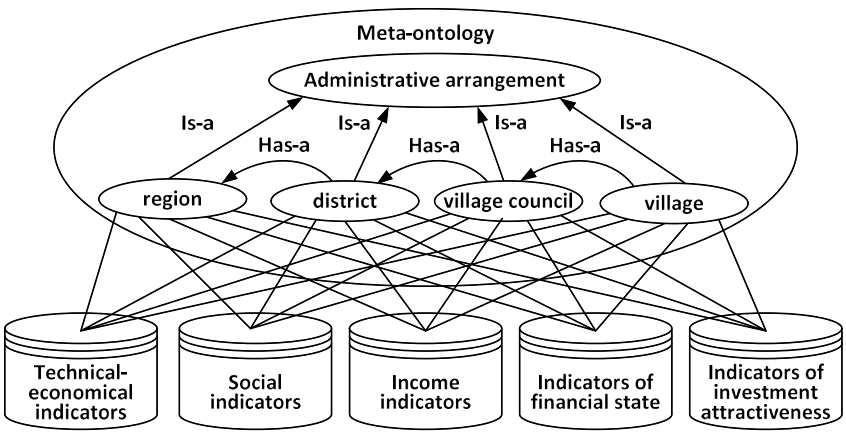

Fig. 3. Information model of regions certification

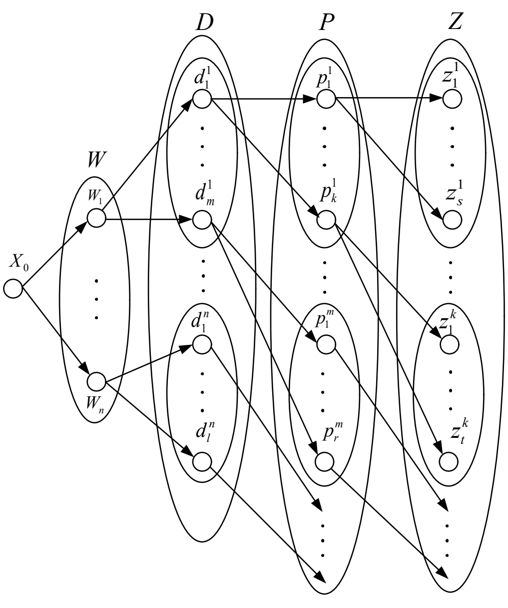

Fig. 4. Commutative diagram of ontology of administrative units

Thus, such classifiers may be regarded as orderly sets of tautologies, based on which the taxonomies of the DA ontology can be created.

As an example of practical research results, consider solving the analytical problem of monitoring the socio-economic development of the regions in a country. Such a task can be considered as a typical informational-analytical problem in administrative management. The primary taxonomy of the problem, which is the meta-ontology, will be comprised of administrative units – region, district, village council, and village. Each of the administrative units has a complex structure and can also be represented by certain ontologies. These units have the associative property, that is, can be defined as classes, where concepts are certain terrain characteristics.

The meta-ontology ensures further certification of objects, in particular, in the agricultural sector of the country, with a view to accounting the indicators of socio-economic development of regions, which include the indicators of techno-economic and social information, revenues of local budgets, financial state of enterprises, investment attractiveness of a region, etc. (Fig. 3).

Meta-ontology O_{agr} of the DA can be represented based on (1) in the following form:

$$O_{agr} \equiv (W, D, P, Z), R_t, F, \tag{9}$$

where $(W,D,P,Z) \equiv X$, W is the class of concepts of the region level, D is the classes of concepts of the district level, P is the classes of concepts of the village council level, Z is the classes of concepts of the village level; R_t is the set of taxonomy relations; F is the set of functions that ensure the solution to problem ***T***.

It is clear that

$$Z \subset P \subset D \subset W. \tag{10}$$

The association property for classes *W, D, P, Z* can be defined based on the application formulas (2) and (10). Commutative diagram of ontology O_{agr} is shown in Fig. 4.

Then, given (4), the problems of this IAS can be determined in the following general form:

$$T \equiv ((W, D, P, Z), A, R_t, F, F \times R_t). \tag{11}$$

Considering the process of solving the IAS problems in terms of using a certain knowledge totality, we will bring the provisions of the theory of knowledge economy management [21] concerning certain classes ((5) to (7)). According to one of the provisions of the specified work, the sum of structural numbers *W*+*D*+*P*+*Z* gives the length of the path of access to the object. The average value of the length of the path for all objects determines entropy (degree of order) of system objects.

Thus, to form the ontology of such administrative system of the state level, it is enough to determine 4 classes. These classes have the associative property and can therefore form categories of species that are shown in Fig. 4.

This rule will be called the rule of structural index. It goes about the feature of the totality of characters, which will be called the structural index. These characters are the names of the concepts of the DA ontology. Character ¤ is assigned to structural index by analogy with character No. as a "sequence number" in the orderly list of objects, for example, in a database. (The first level of a hierarchy consists of a single element and does not require a separate designation).

More than 30 characters are required to list the elements in a class. It is generally accepted to combine the numbers and letters of the Latin alphabet used, for example, in the sixteen-year-old numeral system or used in research [18]. In the considered IAS, all ten digits, 26 capital and 26 lowercase letters of the Latin alphabet are used, in total, 62 characters. To avoid ambiguity, we will call this series of characters as "series 62".

Thus, the ontologies of the administrative-territorial division of the country (the set of domain area concepts) consist of the classes of four levels of the hierarchy {*W*, *D*, *P*, *Z*}. Each of the levels includes the names of the objects in the symbolic form, where each character can accept a specific value from series 62.

Using such system, the regions of a country receive structural indices, beginning from ¤1,000 and to the necessary boundaries.

Take, for example, Ukraine where the administrative-territorial division consists of regions, districts, village councils, and villages. Then, for example, the village of Hvozdiv in the Kyiv region of Ukraine will have structural index ¤A7C1 (Fig. 5). This means that the village of Hozdiv is the first village in the list of Hvozdiv village council, which has structural index ¤A7C0. In turn, this village council is the twelfth in the list of village councils of Vasilkiv district, which has structural index ¤A700. Finally, the specified district is the seventh district in the list in Kiev region, which has structural index of ¤A000.

In this way, the possibility of listing all settlements of the country with the exact specification of its administrative subordination is ensured. The example of the interface of IAS certification of the country's territories, which is based on the proposed knowledge structure, is shown in Fig. 6.

The peculiarity of the ontological model, as it was indicated, is a link to the structure of the relations of concepts of attributive data. This advantage, unlike the solution of the classical data indexing problem, enables the user to use all the necessary information regarding the object. The access to the similar attributive data (the passport of the object, its geographical location, certain socio-economic indicators), for example, is shown in Fig. 5 through the key elements of the interface (right column).

The administrator of the IAS data also receives the advantages of such way of solving the certification problem. The new data model greatly expands the system's capabilities in various aspects, in particular, in the issue of data integrity support, given the use of the history change, the ability to work with different data sources. The procedures, used in the construction of the model, also ensure a significant increase in system performance.

The solution to more detailed analytical problems, related to processing the data on different indicators of the region's state, is ensured by the use of ontologies of domain areas. The example of such an ontological model in the form of the semantic network for the super-class "district" is shown in Fig. 7.

The descriptions of domain areas of the indicators of the state of a region are related by ontological systems. In Fig. 6, they are: O^{tec} – technical-economic indicators, O^{soc} – social indicators, O^{inc} – indicators of the income part, O^{fin} – indicators of the financial state, O^{inv} – indicators of investment attractiveness, etc. The corresponding classifications are created by the concepts of the ontologies of the specified DA. The example is the classifier of the indicators of the social-economic development of regions (Fig. 8).

Classifiers are intended for accounting the corresponding indicators – the units of metadata (samples), which are characterized by their name and the unit of measurement. Indicators describe a certain aspect of socio-economic development and have a clear hierarchical code in the classifier.

Indicators can be united into groups of indicators (subclasses), which in turn can be united into top-level sections (classes) and so on (super-classes). The number of levels of nesting can be unlimited.

With the purpose of harmonization of the given classifier with the statistical reference books of the European Statistics Office (Eurostat), two peculiarities of European statistics are taken into consideration in the model of the classifier. Firstly, Eurostatistics usually operates the "basic" indicator and its several dimensions, which reflect its certain aspects. For example, the indicator "population distribution" may have dimensions of "gender", "age", "measurement method", and so on. Secondly, the "dictionary" approach to the construction of the classifier is used in Europe.

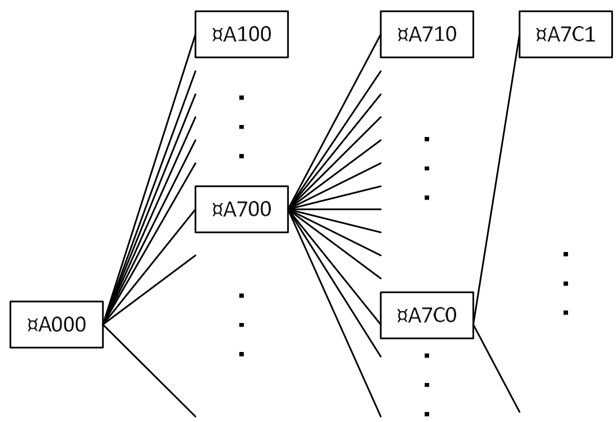

Fig. 5. The fragment of the ontograph of administrative-territorial division

Fig. 6. Panel of informational-analytical system of certification of rural areas

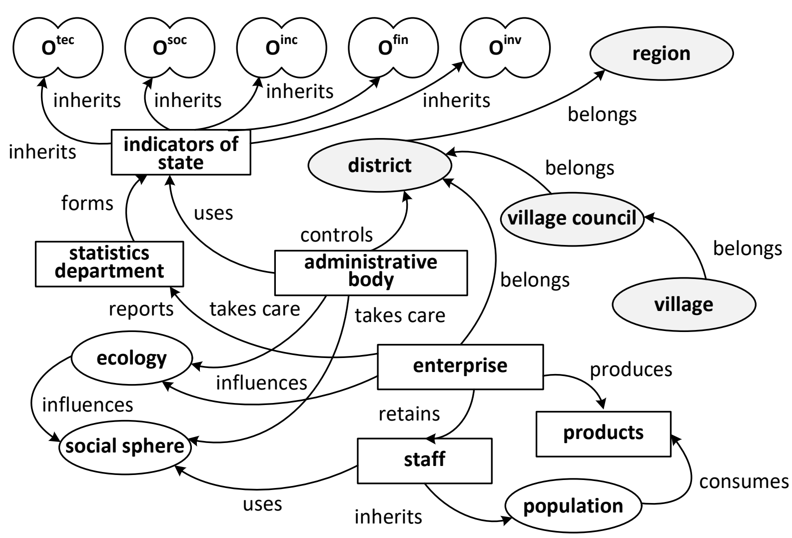

Fig. 7. Ontological model in the form of the semantic network for the super-class "district"

The model of the classifier implies keeping various dictionaries (measurement unit, measurement method, branch of industry, financial results, age groups, metal products, etc.). This approach makes it possible to associate the set of meanings from these dictionaries with one entry in the database. This prospect is an exceptionally significant optimization both in terms of structure and orientation in the classifier, and in terms of speed and the occupied space on carriers. The conceptual model of the indicators of socio-economic development of regions that are given to the classifier is shown in Fig. 9.

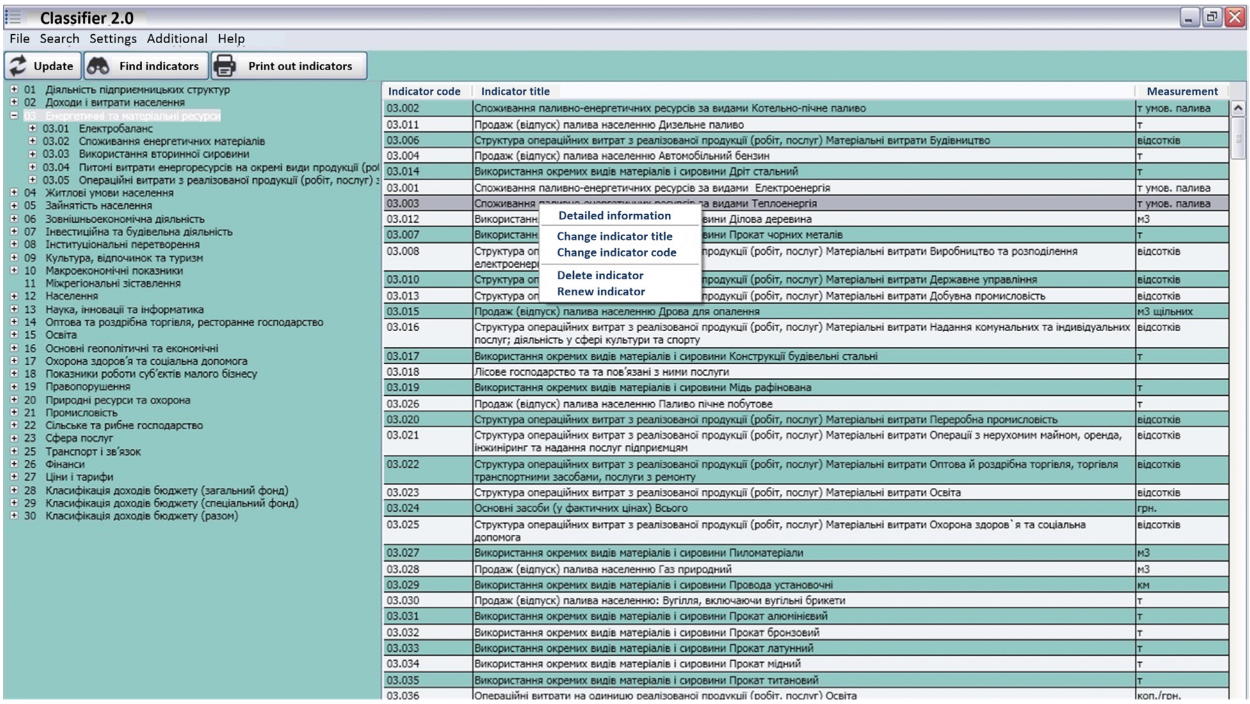

Fig. 8. The classifier of indicators of socio-economic development of regions

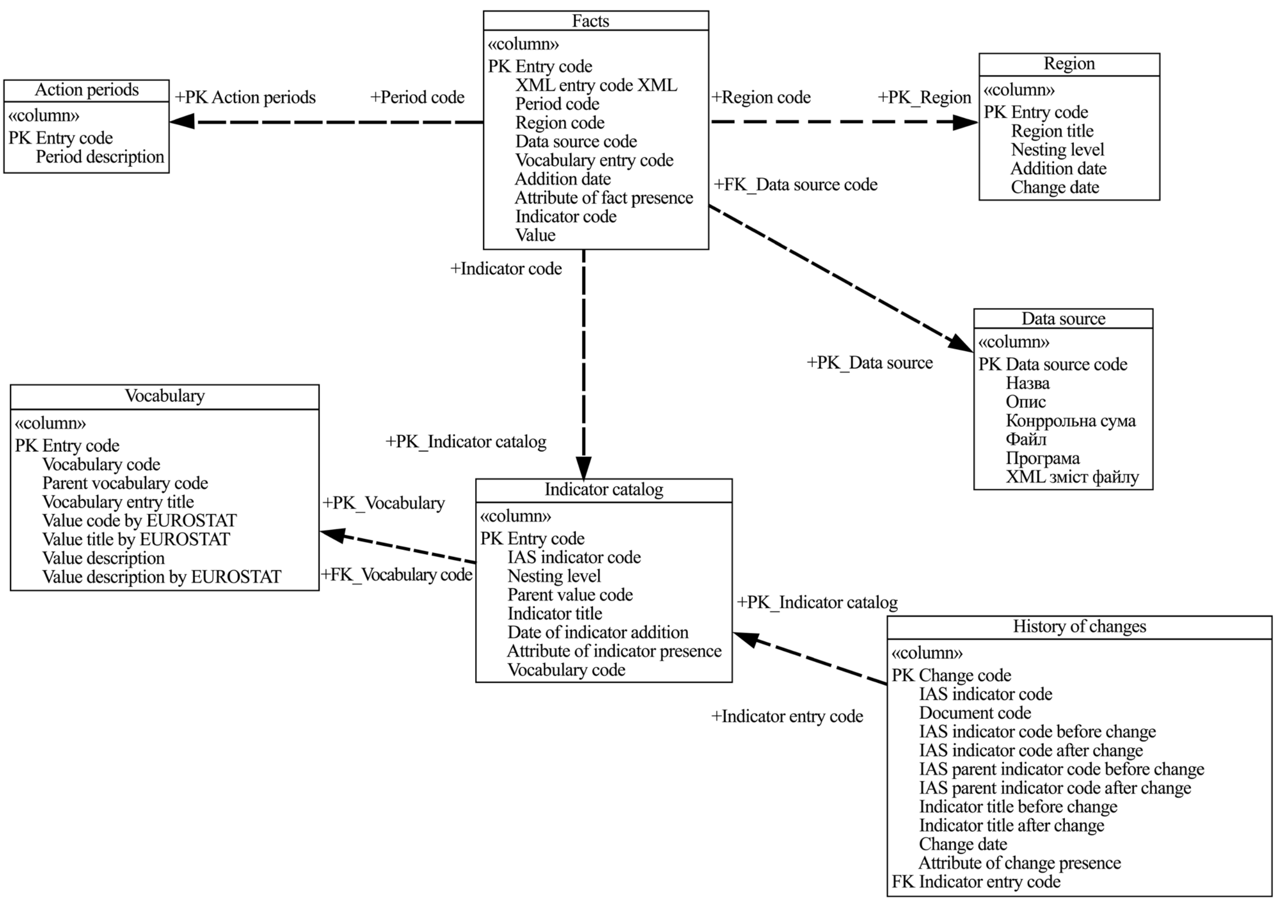

Fig. 9. Conceptual model of the indicators of socio-economic development of regions assigned to the classifier

The constructed model for storing the indicators of socio-economic development of regions takes into consideration the characteristic features of keeping the data on socio-economic development. First of all, attention is paid to the fact that the changes are quite often entered in the classifier (every few days). These changes may be caused by certain normative documents, or simply by routine work of operators (in the case of development of the own lassifier). As a result, a complete history of changes in indicators with the possibility to review and rollback should be kept. Finally, the operations of selecting all direct and/or indirect descendants, obtaining complete textual information about all parental indicators should be fast enough and not load the database server, as they are used very often.

6. Discussion of results of studying the use of ontologies in the informational-analytical activity in administrative management

The obtained results on the use of ontologies in the informational-analytical activity in administrative management indicate that the proposed approach makes it possible to form effectively the information environment of the expert-analyst's activity. Indeed, these practical results (Fig. 6, 8) show that considerable data collections, on which it is possible to carry out analytical research, are accessible to an analyst. In addition, it should be noted that the effectiveness of these studies and of future decisions depends on the constructed ontology system.

In turn, it follows that the obtained result is explained by the removal of the contradiction between the necessity of achieving high efficiency of analytical research and the speed of carrying it out, inherent in the sphere of administrative management, and the need for the access to a significant volume of diverse data, which usually takes a lot of time. It becomes possible to solve these problems due to the use of the method for multi-ontological descriptions of the data associated with the state of domain areas and their extension by associative ontology classes with such information resources as classifiers. That is why the proposed approach should be recognized as promising.

These conclusions can be developed by the advantages of data administration, which is proved by the example of the classifier of indicators of socio-economic development of regions containing more than 12 thousand names. When working with indicators, it is essential to take into consideration their history (change of names, codes, entry or deletion), as well as to link the codes of the indicators and normative documents, according to which the changes occurred. It is also necessary to provide for the possibility to realize the storage of the history of changes of not only the indicators of socio-economic development, but also of other indicators. In addition, it is necessary to enable the user to work with different data sources.

Finally, the issue of controlling the data integrity deserves attention, because in the currently existing models, this control is very weak and does not meet the requirements for the systems of such level.

All of the above problems cannot be resolved within the traditional approaches through the imperfection of the data model, so the new data model based on ontologies will be more modern, relevant and will meet all the requirements. Its use in the administrative control bodies greatly facilitates and accelerates the information component of the analytical process and provides for all the necessary prerequisites for effective decision making.

Of course, there is some room left for improvement of the obtained model. One of the directions is the development of temporal ontologies. The idea is to make ontologies suitable for modeling the dynamics of changes in domain areas, and actually the IAS itself. The change in the DA properties requires considering sets X, R as temporal functions. The task gets complicated by the fact that the set of functions of interpretation F can also depend on time. Solving a similar problem may be the direction of further exploration.

At the same time, it should be borne in mind that technological development led to the fact that knowledge increasingly acquire the trans-discipline features [17, 22]. Under these conditions, ontology is the primary paradigm of structuring information. Ontologies are given a specific role, in particular, in the creation of ontological-controlled information systems. The paradigm of combination of trans-discipline properties and ontological control involves the construction of a unified knowledge system that is capable to ensure the formalized statement and solution of complex analytical tasks of any complexity. Apparently, this prospect is decisive for the sphere of administrative control.

7. Conclusions

1. The proposed approach is based on establishing the cause-effect relations between all sorts of data, which fully complies with the basic technology of analytical activity in administrative management. At the same time, the proposed approach opens up additional opportunities for ensuring the dynamic formation of corresponding sets based on the use of properties of domain areas concepts, by which analytical research is carried out.

2. To support the process of solving information and analytical problems, the concepts and relations in ontological terminology are interpreted in accordance with generally meaningful interpretation functions, corresponding to the given domain area. The distinctive feature of this approach is that the process of solving an analytical problem can represent a certain sequence of ordered tautologies, each of which inherits all the properties of the concepts that constitute the tautology that precedes it. This peculiarity of the method makes it possible to consider the set of states for solving an analytical problem as a sequence of orderly tautologies that determine the set of possible taxonomies.

3. We proposed the methodology of eliminating the contradiction between the necessity of achieving high efficiency of analytical research and the speed of conducting it, inherent in the sphere of administrative management and the need for access to a significant volume of diverse distributed data. The solution of these problems becomes possible due to the use of the method for multi-ontological data descriptions associated with the state of domain areas and extending them by linking ontology classes to such information resources as classifiers.

4. The proposed scheme of practical realization of the decisions obtained based on the typical analytical problems can be implemented in the structure of informational-analytical systems of administrative management

bodies. The correctness and adequacy of such decision is proved by the application of this paradigm to the problem of administrative monitoring of socio-economic state of territories at all levels – from the state level through the regional level and close to the local level. A characteristic feature of such schematic solutions is the knowledge system formed based on the analysis of the properties of the monitoring object, outlined in the regulatory documents and statistical collections of documents. This fully describes the arrangement, structure, and socio-economic indicators of the state of administrative-territorial regions of the country.

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