Journal of Computer Science

Original Research Paper

Logic and the Mathematic Model of the Subject-Area Description for Corporate Information Systems

Konstantin Yurievich Maslenikov and Georgiy Ivanovich Revunkov

Department of Systems of Information Processing and Administrating, Bauman Moscow State University, Moscow, Russia

Article history
Received: 18-08-2021
Revised: 04-12-2021
Accepted: 15-01-2022

Corresponding Author:
Konstantin Yurievich Maslenikov
Department of Systems of Information Processing and Administrating, Bauman Moscow State University, Moscow, Russia
Email: k.yu.maslenikov@yandex.ru

Abstract: Aiming to build and receive a logic-mathematical substantiation and model of the process of constructing the description of any subject area for corporate information systems, the authors divided the subject area for building the system into constituent elements and the relationships between them. Using discrete mathematics methods to the graphs and two-seater predicates of the first order, we built an interconnected model of the subject area. Logical and mathematical models were built upon the main components of the subject area. Based on a technique used to construct its description, the use of the graphical description, combined with the application of transformation in a semantic model of the predicate type, allows us to use further the received model for constructing the normalized databases. The research reveals that constructing the qualitative description of the subject domain of the corporate automated information system requires us to use some consecutive iterations. Logic and mathematical models allow us to construct a general view of the description of the subject area of the corporate automated information system. Further, this generalized model can be transferred to absolutely any concrete subject area. The advantage of constructing the description of the subject area in the form of the predicate type's semantic model is the integral sight at all considered subject areas, as information representation in the integral form is better perceived. When constructing such a graph, there is a possibility of completely restoring missing logical links. The purpose of the research is to describe the subject area of the corporate system using the graph form of representation. The novelty lies in developing information support model designed for managing processes of acquiring and using knowledge (this model allows to consider usefulness of information elements and didactic connections between elements) and in approach to estimation of achieving information support goals with the use of graphs describing the subject area of corporate system.

Keywords: Model, Description, Subject Area, Automated Information System, Mathematical Justification, Semantic Model, Logic, Predicate

Introduction

Building a description of the subject area is an important element in the design of any system, even the simplest one. As has been considered in the article of Maslenikov *et al.* (2017), there is a considerable quantity of techniques and methods for constructing the description of the subject domain of corporate information systems.

The purpose of this study is to expand the method of constructing a description of the subject area using a semantic network of predicate type (Revunkov and Maslenikov, 2016; Maslenikov *et al*., 2017; Kettinger and Yuan, 2010) by introducing a logical and mathematical model to obtain a formal description of the subject area, using the mathematical model.

One of the factors that makes methods of working with big data more accessible to a wide range of is the availability of a large number of libraries that hide the complexity of models behind their software interface. (Imani and Ghoreishi, 2021, Abdel-Karim *et al*., 2021).

On the one hand, this has a positive impact on the speed of implementation and dissemination of new business approaches and their integration into a larger number of key business processes. On the other hand, however, there is a disconnect between the theory and practice of applying machine learning models for

DOI: 10.3844/jcssp.2022.33.41

specialists who only yesterday were developing systems such as document management. This can have a negative impact on the final result of their work when it becomes insufficient to use only standard models that work "out of the box" and it is necessary to calibrate them or even cascade them with other models.

Therefore, to develop the corporate IT infrastructure in the direction of data mining and automation of management decision support, the specialists involved need to learn the root technologies and mathematical apparatus that underlie any library of machine learning models. It will not be possible to solve problems on big data without mastering the patterns of parallel data processing, distributed data storage and scalable multi-threaded algorithms. It is to solve these problems that the developed algorithm for describing the subject domain is aimed at.

Let us introduce some necessary concepts for building a logical and mathematical model. We will understand a part of the real world within the limits of the field of functioning of the developed corporate automated information system as a subject area, or the Model of the Subject Area (MSA). In the offered technique, the subject domain is divided into parts. Thus, the subject domain in a technique is understood as the following model, consisting of the following interconnected parts: (1) The Fundamental Model of the Subject Area (FMS); (2) the Substantial Model of the Subject area (SMS); and (3) the Conceptual Model of the Subject area (CMS).

The FMS is a set of fundamental concepts to which real-world objects correspond, presented as (1) an oriented marked graph and (2) the relationship between the concepts. Based on this definition, we obtain the following formal definition of the conceptual model.

The SMS, consisting of a marked graph (the tops of which are information elements), specifically implements fundamental concepts or their characteristics. Based on this definition, we obtain the following formal definition of the content model.

The CMS is an abstract description of a fragment of the real world and the conceptual model, which is obtained from identifying concepts (properties) inherent in this fragment and indicating their attributes (permissible values) and possible links between them. Based on this definition, we obtain the following formal definition of the conceptual model.

As a result of unifying the three models-FMS, SMS and CMS-and their interrelationships, we receive the Model of the Subject domain (MSA).

The constituents of these three models are given in the article of Maslenikov *et al.* (2017). Further on its basis and (Belousov and Tkachev, 2015; Boyarintseva *et al*., 2011; Zykov *et al*., 2013; Bolotova, 2012), we shall enter the logical-mathematical model of the construction of the subject area of the corporate automated information system, using graphs and double predicates.

Materials and Methods

Building a description of the subject area is an important element in designing any system, even the simplest one. As has been considered in the article of Maslenikov *et al.* (2017), there is a considerable quantity of techniques and methods for constructing the description of the subject domain of corporate information systems.

The purpose of this study is to expand the method of constructing a description of the subject area using a semantic network of predicate type (Revunkov and Maslenikov, 2016; Maslenikov *et al*., 2017; Kettinger and Yuan, 2010) by introducing a logical and mathematical model to obtain a formal description of the subject area, using the mathematical model.

Let us introduce some necessary concepts for building a logical and mathematical model. We will understand a part of the real world within the limits of the field of functioning of the developed corporate automated information system as a subject area, or the Model of the Subject Area (MSA). In the offered technique, the subject domain is divided into parts. Thus, the subject domain in a technique is understood as the following model, consisting of the following interconnected parts: (1) The Fundamental Model of the Subject area (FMS); (2) the Substantial Model of the Subject area (SMS); and (3) the Conceptual Model of the Subject area (CMS).

The FMS is a set of fundamental concepts to which real-world objects correspond, presented as (1) an oriented marked graph and (2) the relationship between the concepts. Based on this definition, we obtain the following formal definition of the conceptual model.

The SMS, consisting of a marked graph (the tops of which are information elements), specifically implements fundamental concepts or their characteristics. Based on this definition, we obtain the following formal definition of the content model.

The CMS is an abstract description of a fragment of the real world and the conceptual model, obtained from identifying concepts (properties) inherent in this fragment and indicating their attributes (permissible values) and possible links between them. Based on this definition, we obtain the following formal definition of the conceptual model.

As a result of unifying the three models-FMS, SMS and CMS-and their interrelationships, we receive the Model of the Subject domain (MSA).

The constituents of these three models are given in the article of Maslenikov *et al.* (2017). Further on its basis and (Belousov and Tkachev, 2015; Boyarintseva *et al*., 2011; Zykov *et al*., 2013; Bolotova, 2012), we shall enter the logical-mathematical model of the construction of the subject area of the corporate automated information system, using graphs and double predicates.

DOI: 10.3844/jcssp.2022.33.41

Results

Building a description of the subject area is an important element in the design of any system, even the simplest one. As has been considered in the article of Maslenikov *et al.* (2017), there is a considerable quantity of techniques and methods for constructing the description of the subject domain of corporate information systems.

The purpose of this study is to expand the method of constructing a description of the subject area using a semantic network of predicate type (Revunkov and Maslenikov, 2016; Maslenikov *et al*., 2017; Kettinger and Yuan, 2010) by introducing a logical and mathematical model to obtain a formal description of the subject area, using the mathematical model.

Let us introduce some necessary concepts for building a logical and mathematical model. We will understand a part of the real world within the limits of the field of functioning of the developed corporate automated information system as a subject area, or the Model of the Subject Area (MSA). In the offered technique, the subject domain is divided into parts. Thus, the subject domain in a technique is understood as the following model, consisting of the following interconnected parts: (1) The Fundamental Model of the Subject area (FMS); (2) the Substantial Model of the Subject area (SMS); and (3) the conceptual model of the subject area (CMS).

The FMS is a set of fundamental concepts to which real-world objects correspond, presented as (1) an oriented marked graph and (2) the relationship between the concepts. Based on this definition, we obtain the following formal definition of the conceptual model.

The SMS, consisting of a marked graph (the tops of which are information elements), specifically implements fundamental concepts or their characteristics. Based on this definition, we obtain the following formal definition of the content model.

The CMS is an abstract description of a fragment of the real world and the conceptual model, which is obtained from identifying concepts (properties) inherent in this fragment and indicating their attributes (permissible values) and possible links between them. Based on this definition, we obtain the following formal definition of the conceptual model.

As a result of unifying the three models-FMS, SMS and CMS-and their interrelationships, we receive the Model of the Subject domain (MSA).

The constituents of these three models are given in the article of Maslenikov *et al.* (2017). Further on its basis and (Belousov and Tkachev, 2015; Boyarintseva *et al*., 2011; Zykov *et al*., 2013; Bolotova, 2012), we shall enter the logical-mathematical model of the construction of the subject area of the corporate automated information system, using graphs and double predicates:

$$\exists M_{SA} \Rightarrow \exists! FMS \Rightarrow \exists FN_{i,} \exists E_{ij_{i=\overline{1,n},j\,i=\overline{1,n},t\neq j}} \tag{1}$$

$$\exists M_{SA} \Rightarrow \exists! SMS \Rightarrow \exists RP_{i,i=\overline{1,m},} \tag{2}$$

$$\exists M_{SA} \Rightarrow \exists! CMS \Rightarrow \exists S, \exists V_{ji=\overline{1,k},j=\overline{1,p}} \tag{3}$$

Formulas (1)-(3) reflect the main components and the uniqueness of parts of the MSA. Let us consider, in order, the corresponding parts of the domain of the MSA.

Modeling the logical and mathematical model of the process of building a fundamental model. From the existence of the fundamental model and formula (1), we obtain:

$$\exists FN_{1,\ldots,} \exists FN_{i,\ldots,} \exists FN_n \rightarrow \{FN_i\}_{i=\overline{1,n}} \tag{4}$$

$$\exists FN_i, \exists FN_j = \exists Ei_j := FN_i\ FN_{j,i=\overline{1,n},\ j=\overline{1,n},i\neq j} \tag{5}$$

Formulas (4) and (5), generate a set of arcs of the fundamental model expressed in the graphical representation:

$$E_{ij}\left(FN_i, FN_j\right)_{,i=\overline{1,n},\ j=\overline{1,n},i\neq j} \tag{6}$$

The rules of transformation of the graph form of representation of the conceptual model of the subject domain can now be introduced into a predicate type of semantic network. Recall that the predicate (Boyarintseva *et al*., 2011; Devyatkov, 2001; Gavrilova *et al*., 2012) consists of the following components, which are presented in expression (7):

$$P = \{P, N, (T1, T2)\} \tag{7}$$

where P is the predicate symbol, N is the name of the predicate symbol, T_1 is the first term and T_2 is the second term.

The corresponding logical and mathematical expressions for conversion are given in formulas (8)-(10). After performing the corresponding actions, the predicate is presented in formula (11).

$$\begin{gathered} E_{ij} \rightarrow Pred\left("\,part - some"\right)_{k_i\ =\overline{1,n},\ j,=\overline{1,n},i\neq j,k=\overline{1,k}} \\ OR \\ E_{ij} \rightarrow Pred\left("is - \alpha"\right)_{k_{i=\overline{1,n},\ j,=\overline{1,n},i\neq j,k=\overline{1,k}}} \end{gathered} \tag{8}$$

$$E_{ij} \rightarrow P_{ki=\overline{1,n},\ j,=\overline{1,n},i\neq j,k=\overline{1,k}} \tag{9}$$

$$FNi \rightarrow T_{1ik}, FN_j \rightarrow T_{2jk,i=\overline{1,n},j=i\neq j} \tag{10}$$

$$p_k \Pr ed_K \left(T_{1k}, T_{2k}\right)_{k=\overline{1,k}} \quad (11)$$

The results demonstrate that *Eij's* relationship between FN_i and FN_j can be trans-formed into a predicate symbol name with the corresponding concepts transforming into the first and second terms.

From the formula (2) and the existence of a substantial model of the subject area, we will get the following logical and mathematical expressions:

$$\exists RP_{1,...,}\exists RPl,...,\exists RP_m \rightarrow \{RPl\}_{l=\overline{1,m}} \quad (12)$$

$$\sim \forall FN_i = \exists RP_{l,i=\overline{1,n},l=\overline{1,m}} \quad (13)$$

Because of the analysis of formulas (12) and (13), we conclude that not every concept of the fundamental model of the subject domain is connected to or contains a specific implementation in the substantial model of the subject domain. Therefore, let us introduce the following limitation in formula (14), which expresses the previous remark.

$$\sim \forall FN_i := \{RP\} \vee \{\phi\}_{,i=\overline{1,n},l=\overline{1,m}} \quad (14)$$

The fundamental and substantial models of the subject domain are related to each other, which reflects formula (13). The following relations are obtained:

$$\begin{gathered}\left(\left(\forall RPl \Rightarrow \exists! FN_i\right) \wedge \left(\forall RPl \Rightarrow \exists FN_j\right)\right) \\ \Rightarrow \exists Sv_1 :== FN_i \wedge RP_{l\,l=\overline{1,m},i=\overline{1,n},j\overline{1,n},i\neq j}\end{gathered} \quad (15)$$

$$Sv_1 = \{there\ is\ some\}_k \left(FN_i, RPl\right)_{i=\overline{1=n},l=\overline{1=m},k=\overline{k+1,z}} \quad (16)$$

Formulas (15), (16) reflect the relationship between the specific implementation of the RP_l of the content model and the concept of FN_i fundamental model of the subject area.

For conversion to the semantic model of predicate type, the following logical relations are employed, which are provided in formulas (17)-(19). Consequently, we obtain a predicate (20) for the semantic model.

$$S_{1k} \rightarrow Pred_{k\,k=\overline{k+1,z}} \quad (17)$$

$$Sv_{1k} \rightarrow P_{ki=\overline{1=n},j=\overline{1=n},i\neq j,k=\overline{k+1,z}} \quad (18)$$

$$RP_l \rightarrow T_{1k}, FN_i \rightarrow T_{2k},_{i=\overline{1,n},l=\overline{1,m},k=\overline{k+1,z}} \quad (19)$$

$$P_k\, Pred_K \rightarrow \left(T_{1k}, T_{2k}\right)_{k=\overline{k+1,z}} \quad (20)$$

Thus, the relationship between the concept of FN_i of the fundamental model and the specific implementation of the RPl of the content model can be transformed into the name of the predicate symbol and the related elements RPl and FN_i into first and second terms respectively.

Modeling of the logic-mathematical model of the process of construction of a conceptual model. From formula (3) and the existence of the conceptual model of the subject area, we receive the following logic-mathematical expressions:

$$\exists S_1,...,\exists S_i\ S_i,...,\exists S_g \rightarrow \{S_i\}_{i=\overline{1,g}} \quad (21)$$

$$\exists v_1,...,\exists V_j,...,\exists V_p \rightarrow \{V_j\}_{j=\overline{1,p}} \quad (22)$$

Each property of the concept of the fundamental model of the subject domain contains a set of acceptable values. Any value may possess some property, which is reflected in the formulas (23), (24).

$$\forall S_i = \exists V_j : S_i \rightarrow V_{j,i=\overline{1,g},j=\overline{1,p}} \quad (23)$$

$$\sim \forall Vj \Rightarrow \exists S_f : V_j \rightarrow S_{f,f=\overline{1,g},j=\overline{1,p}} \quad (24)$$

The conceptual model of the subject area is connected with both the conceptual model and the substantial model. The first interrelation of the model is achieved due to the relation between the concept *FN*i and the property *Sj* (25), (26); the second relation is achieved due to the relation between the concrete implementation *RPi* and the permissible value *Vj* (27), (28).

$$\left(FN_i + S_k\right) \Rightarrow \exists Sv_2 := FN_i \wedge S_k \Rightarrow FN_i \rightarrow S_{ki=\overline{1,n},k=\overline{1,g}} \quad (25)$$

$$Sv_2 = \{thereisproperty\}_k \left(FN_i, S_k\right)_{i=\overline{1,n},k=\overline{1,g},k=\overline{k=z+1,x}} \quad (26)$$

$$\left(RP_l + V_f\right) \Rightarrow \exists Sv_3 := RP_l \wedge V_f \Rightarrow RP_l \rightarrow V_{fl=\overline{1,m},f=\overline{1,p}} \quad (27)$$

$$Sv_3 = \{thereisvalue\}_k \left(RP_l, V_f\right)_{i=\overline{1,m},f=\overline{1,p},k=\overline{k=z+1,x}} \quad (28)$$

To transform the graph of the conceptual model of the subject area in the semantic model of the subject area it is necessary to use logical and mathematical formulas (29)-(31), as a result we get a predicate (32):

$$S_i \rightarrow \Pr ed_k\,_{k=\overline{z+1,x},i=\overline{1,g}} \quad (29)$$

$$\left(RP_l \rightarrow T_{1K}\right)V\left(V_j\,(S)T_{1K}\right)V\left(FN_i \rightarrow T_{1K}\right),_{i=\overline{1,n},l=\overline{1,m},j=\overline{1,p},k=\overline{z+1,x}} \quad (30)$$

DOI: 10.3844/jcssp.2022.33.41

$$V_j \rightarrow T_{2k}, j = \overline{1, p}, k = \overline{z+1, x} T_{2k} \rightarrow P_{k\ k=\overline{z+1,x}} \quad (31)$$

$$P_k \ \text{Pr}ed_K \left(T_{1k}, T_{2k}\right)_{k=\overline{z+1,x}} \quad (32)$$

We can transform property of concepts from a conceptual model of the subject area in the name of predicate symbol and concrete realizations *RP*l - in the first term (if there is a connection between substantial and conceptual models), concept FN_i - in the first term (if there is a connection between fundamental and substantial models), permissible value *Vj* - in the first term if the connection between permissible value and property is transformed (if permissible value contains property), otherwise - in the second term (32).

Let us describe more generally the formalized logic-mathematical model of the method:

1. Construction of the fundamental model:

    a. Identification of general concepts of the subject area (Fig. 1, formula 4)
    b. Getting the subject area graph (Fig. 2, formula 5)
    c. Getting the arcs of the graph (formula 6)
    d. Conversion of arcs of the graph into two-seat predicates (formulae 8 - 11)
    e. Construction of a semantic network of predicate type (Fig. 3)

2. Construction of a substantial model:

    a. Identification of specific implementations of the subject area (Fig. 4, formula 12)
    b. Grouping of specific implementations of the subject area (classification by fundamental concepts) (Fig. 5, formulas 13, 14)
    c. Determining the relationship between fundamental and substantial models of the subject area (formula 15, 16)
    d. Construction of a semantic network of predicate type (Fig. 6, formulas 17 - 20)

3. Construction of a conceptual model:

    a. Identification of specific features and properties of the concepts of the subject area (Fig. 8, Formula 21 - 24)
    b. Determining the relationship between fundamental and conceptual models of the subject area (Fig. 7, formulas 25, 26)
    c. Determining the relationship between substantial and conceptual models of the subject area (Fig. 9, formulas 27, 28)
    d. Construction of a semantic predicate network for the conceptual model of the subject area (Fig. 10, formula 29 - 32)

Because of the association of fundamental, substantial and conceptual models with all interrelations in a uniform model, we receive a model of the subject area in the form of graph model and semantic model of predicate type, which with ease through some rules can be displayed in other models. These rules will be developed in the following work.

Discussion

However, for the qualitative construction of the subject area and its evaluation, some criteria for qualitative analysis should be introduced. Usually, several specialists are involved in the construction of the subject area, so when modeling the subject area with the help of collective technology it is built based on some basic method (described above) for modeling and involves the construction of the following interrelated models:

- Building a basic functional model
- Building an improved functional model
- The formation of a glossary of essentials of the subject area
- Verification of the model built, identification of system-wide components
- Building a conceptual data model

Building a base model. On the given step of model working out of functional requirements of the future system by several analysts in a parallel mode occurs, there is an organized conducting glossary of documents, however full structure of attributes of the subject area is absent, the depth criterion of the description of the functional model of the subject area is entered.

Building an improved functional model of the subject area. This step checks the model for consistency with the selected criterion of the depth of description of the subject area of the functional model, correcting the glossary of documents and integrating private results of modeling the subject area.

Forming a glossary. This step defines the informational essence of the subject area based on the glossary, checks and integrates the results of parallel work.

Checking the model built. At this step, the integrity of the built model is checked and the adequacy of the built model is checked with the help of expert estimations.

Identification of system-wide components. Based on constructed glossaries with the help of the formalized method, there is an identification of system-wide entities and components and limitation of model dimensionality of the subject area with logical integrity.

Construction of a conceptual model of the subject area. Based on the previous step, the essence of the subject area, which is relevant to it as a whole (the conceptual model of the subject area) and facts of the subject area, information about which should be stored, are highlighted.

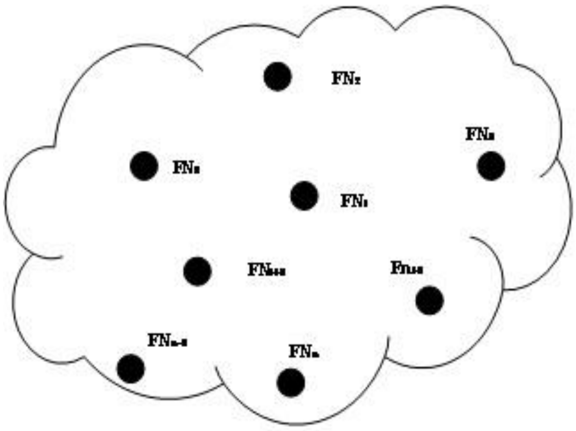

Fig. 1: A Selection of notions in the subject area (Author's drawing)

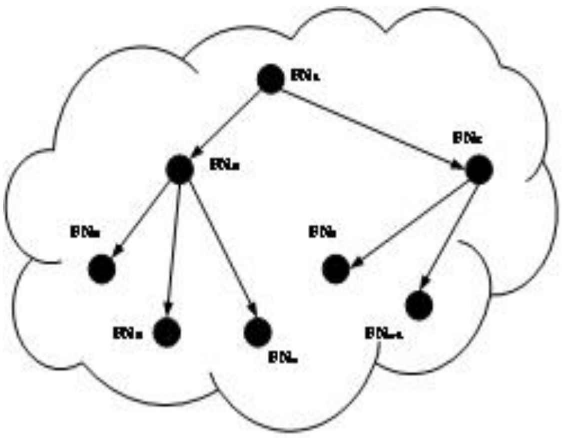

Fig. 2: The subject field graph. (Author's drawing)

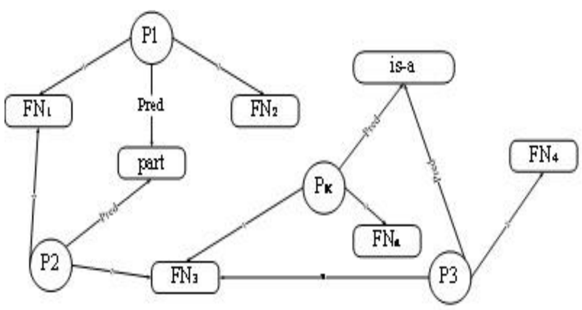

Fig. 3: A formal description of a predicate semantic network for a fundamental model of a subject domain. (Author's drawing)

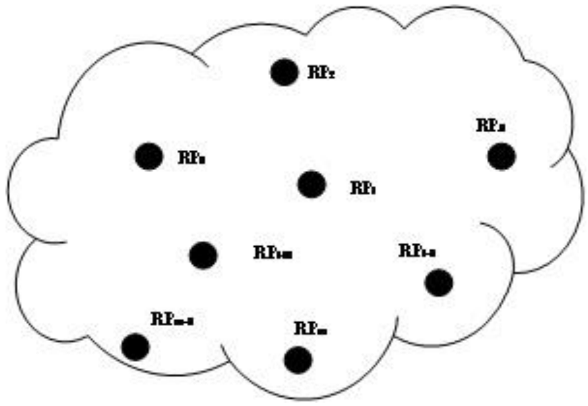

Fig. 4: Selection of specific implementations of the content model. (Author's drawing)

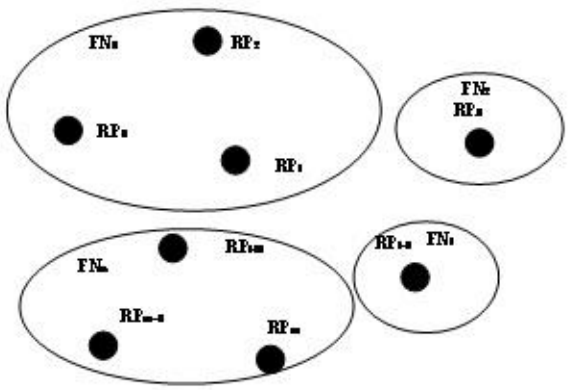

Fig. 5: Grouping of specific implementations of the substantial model. (Author's drawing)

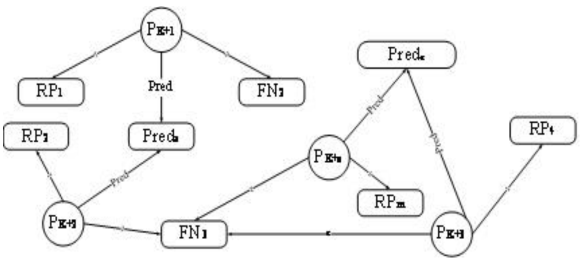

Fig. 6: Predicate semantic network for the substantial model of the subject area (Author's drawing)

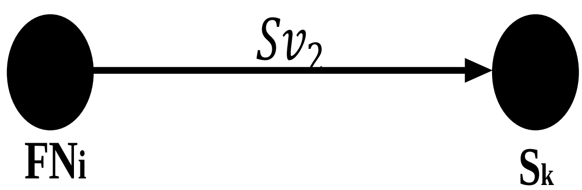

Fig. 7: Relationship between fundamental and conceptual models (Author's drawing)

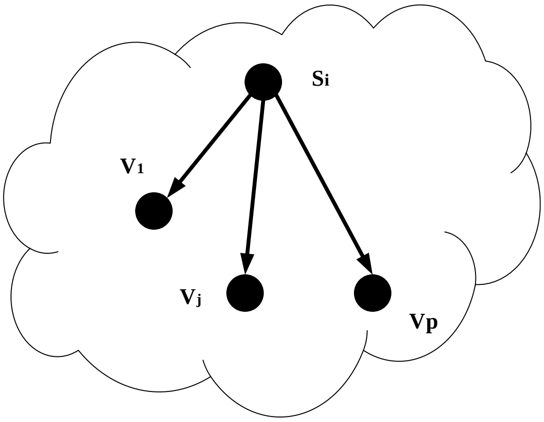

Fig. 8: The initial stage of conceptual model development in the subject area (Author's drawing)

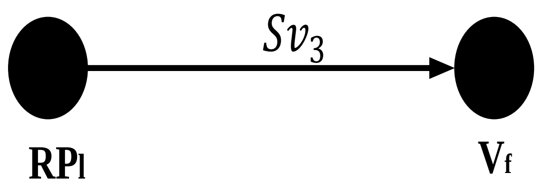

Fig. 9: Relationship between the substantive and conceptual models (Author's drawing)

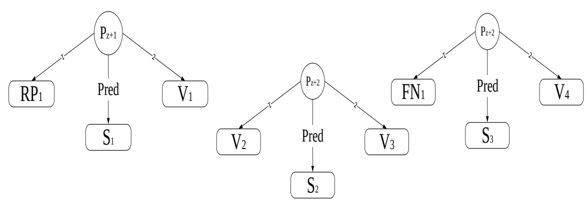

Fig. 10: The semantic network of predicate type for a conceptual model of the subject area (Author's drawing)

For the necessary level of detail of the subject area the depth of description criterion of the subject area is formulated, which promotes: To provide the necessary level of data description for the next steps of modeling, universal for all developers level of abstraction of the considered model of the subject area, limiting the complexity of the functional model under development. Universal level of abstraction serves for logical relationship and integrity of the result of collective modeling. The given criterion is necessary for the removal of excessive detailed elaboration of the model at collective modeling by analysts.

This criterion can be formulated as follows: The lower-level data stream of the model corresponds to one information object of the subject area before its formalization and generalization into abstract categories. Thus, building a functional model of the subject area until all lower-level data flows are written into information objects of the subject area, while the lower-level processes may have different complexity.

The given criterion allows forming glossaries, depth of the description allows carrying out system-wide modeling, uniform level of abstraction and restriction of the complexity of the functional model.

An important step in system design is checking the model at all stages of work on the project. The main tasks of the verification procedures in the analysis of the subject area are as follows: Checking the correlation between the subject area model and the system requirements (an informal process that depends on the quality and presentation of the requirements to start work), Syntax correctness check (performed with the help of analysis and design tools), Checking the semantic correctness of the subject area (checking the subject area for all functional nodes, links between them, data and process specifications), Completeness check (model decomposition was carried out according to formally checked criterion, for example, conformity of processes and functions of elements of organizational structure, a full set of actual documents, initial information objects and formalized objects) and Checking the logical integrity of the subject area (conducted through the integration of parallel work and common glossaries that reflect the information objects of the subject area).

Conclusion

Thus, because of the application of the given technique, we receive the simulated and constructed model of a subject domain in the form of the united scheme, applying semantic networks of predicate type and graphs and metagraphs.

For building a qualitative description of the subject area of a corporate automated information system, it is necessary to use some iterations for constructing each graphical and semantic model.

To check the adequacy of the constructed model, we apply the following criteria:

1. Each document of the subject area must be included in the glossary of documents.
2. Each element of the glossary must be present in the functional model and correspond to at least one element of the glossary of entities.

The main advantages of building a description of the subject area of a corporate automated information system as a semantic network of predicate type are as follows:

- Systemic-a holistic view of the entire subject area under consideration
- Uniformity-presentation of information in a generalized predicate and graphic form; and
- Link recovery-when building such a graph, it is possible to recover missing logical links of the subject area in their entirety

The disadvantage of this method of constructing the description of the subject area is the increasing number of vertices in the graph. The content model description becomes cumbersome and inconvenient to read. Additionally, there is difficulty in distinguishing notions between conceptual and conceptual models of the subject area (Batra and Marakas, 1995).

To solve the first problem, it is possible to depict universal implementations on the graph (Gapanyuk *et al*., 2015; Bahram *et al*., 2017). All others will inherit the necessary links and properties (analog of inheritance in the object-oriented approach). A decision on the second problem is made at the discretion of the person-developer (the engineer on knowledge) who de-scribes the subject area for developing an information system (Wang *et al*., 2016). It also depends on their experience in modeling subject areas of corporate automated information systems.

The novelty of this study is that it seeks to contribute to the current discussion in the literature about the problem of mathematical description of the subject area of the corporate system.

Scientific novelty of the article also lies in the research that describes the theoretical and practical ways of constructing the subject area of the corporate information system developed by the author. Using this toolkit reduces to a large extent the time to develop a conceptual system model of the corporate system, especially in the collective modeling of the description of the subject area.

When building and using several iterations of this method, the quality of the description of the subject area of the corporate automated information system increases.

The results can be used to support decision-making in the acquisition and application of knowledge, namely: When creating information support of production processes, in terms of developing elements of methodological support of information systems, in corporate systems of personnel training; when developing programs of individual professional development courses, as well as sets of programs with their subsequent adjustment; information support of e-learning systems; when forming distance learning programs The implementation of the methodology reduced the likelihood of errors in the collective modeling of the corporate system of individual plans of students by 10%, increased the accuracy and order of mastering the topics of students depending on the level of knowledge.

Implementation of the developed approaches, methods and procedures in the systems to support the processes of acquisition and application of knowledge, mastering the subject area will contribute to the effectiveness of the process of perception of information by users by structuring the subject content, selection of the necessary and sufficient list of information elements, as well as determining on it the order of development that contributes to achieving the objectives of information support using didactic links between the information elements.

Acknowledgement

The authors would like to thank the staff of the Department of Systems of Information Processing and Administrating for their insightful comments on filming the project.

Author's Contributions

Konstantin Yurievich Maslenikov: Is responsible for formal analysis, investigation, resources, data curation, writing-original draft preparation.

Georgiy Ivanovich Revunkov: Is responsible for conceptualization, methodology, supervision, data curation, writing-review and editing.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

References

Abdel-Karim, B., Pfeuffer, N., & Hinz, O. (2021). Machine learning in information systems - a bibliographic review and open research issues. Electronic Markets, 31,643-670. doi.org/10.1007/s12525-021-00459-2

Bahram, L. S., Unver, H. O., Nikghadam, S., Dogdu, E., Ozbayoglu, A. M., & Kilic, S. E. (2017). An ontology-based multi-agent virtual enterprise system (OMAVE): Part 1: Domain modeling and rule management. International Journal of Computer Integrated Manufacturing, 30(2-3), 320-343. doi.org/10.1080/0951192X.2016.1145811

Batra, D., & Marakas, G. M. (1995). Conceptual data modeling in theory and practice. European Journal of Information Systems, 4(3), 185-193. doi.org/10.1057/ejis.1995.21

Belousov, A. I., & Tkachev, S. B. (2015). Discrete math. Bauman Moscow State University Press. ISBN-10: 978-5-7038-3783-2.

Bolotova, L. S. (2012). Systems of artificial intelligence: Models and technologies based on knowledge. Finances and Statistics. ISBN-10: 978-5-279-03530-4.

Boyarintseva, T. E., Zolotova, N. V., & Ismagilov, R. S. (2011). Math logic and algorithm theory. Bauman Moscow State University Press.

Devyatkov, V. V. (2001). Systems of artificial intelligence. Moscow State University Press. ISBN-10: 5-7038-1727-7.

Gapanyuk, Yu. E., Samokhvalov, E. N., & Revunkov, G. I. (2015). Using metagraphs for description semantics and pragmatics of information systems. Bauman Moscow State University Bulletin-Device Building, 1, 83-99.

Gavrilova, T. A., Leshcheva, I. A., & Kudryavtsev, D. V. (2012). Using models of knowledge engineering for training specialists in the field of information technologies. System Programming, 7(1), 90-105. http://www.sysprog.info/2012/05.pdf

Imani, M., & Ghoreishi, S. F. (2021). Two-Stage Bayesian Optimization for Scalable Inference in State Space Models. IEEE Transactions on Neural Networks and Learning Systems, 1-12. doi.org/10.1109/TNNLS.2021.3069172

Kettinger, W. J., & Yuan, L. (2010). The infological equation extended: Towards conceptual clarity in the relationship between data, information and knowledge. European Journal of Information Systems, 19(4), 409-421. doi.org/10.1057/ejis.2010.25

Maslenikov, K. Yu., Revunkov, G. I., & Satova, M. V. (2017). Description of subject area as essential element of designing. Naukovedenie, 9(6), 1-9. https://cyberleninka.ru/article/n/opisanie-predmetnoy-oblasti-kak-neotemlemyy-element-protsessa-proektirovaniya-avtomatizirovannoy-informatsionnoy-sistemy

Revunkov, G. I., & Maslenikov, K. Yu. (2016). Modelling subject area of automated systems. Information-Measuring and Administrating Systems, 14(12), 51-53. https://library.bmstu.ru/Catalog/Details/470175

Wang, J. W., Wang, H. F., Ding, J. L., Furuta, K., Kanno, T., Ip, W. H., & Zhang, W. J. (2016). On domain modeling of the service system with its application to enterprise information systems. Enterprise Information Systems, 10(1), 1-16. doi.org/10.1080/17517575.2013.810784

Zykov, A. G., Polyakov, V. I., & Skorubskij, V. I. (2013). Math logic. ITMO. ISBN-10: 978-5-534-01114-2.