DOI: 10.37943/AITU.2022.90.22.007

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ONTOLOGICAL MODEL OF A DATABASE OF INFORMATION-EDUCATIONAL PORTAL OF THE UNIVERSITY

Abstract: According to the state program "Informational Society 2030", it is planned to develop education on the basis of new progressive concepts of introducing the latest information technologies and scientific and methodological achievements into the educational process.

In order to achieve goals, it is necessary to implement mobilization and effective use of staff and property and technical resources of the university. It is possible if there is purposeful modeling of the information and educational portal of the university.

The choice and design of teaching technology are primarily determined by the type of students' competencies and the characteristics of the planned learning outcomes for each level of competence (knowledge, skills, and experience). Constant improvement of EP content and educational technologies as a key factor of education services quality is a vital demand.

The article considers the issues of the concept of ontology, IDEF-technologies and, based on the ontological model proposed in the article, the architecture of the database of the information and educational portal of the university is developed and classes and properties for the implementation of this model are defined, and a functional model of the university in IDEF0 is developed, which covers all types of university activities, integrates all information flows and forms a single information space.

Keywords: informational and educational portal, ontology, ontological model, functional model, IDEF-technologies, information and analytical system, management.

Introduction

The generalized goal of developing any model can be considered to be obtaining information for making certain decisions with its help. The natural way to increase the informativeness of models by complicating them and detailing them in practice is limited, since for formalized systems, the complexity of which exceeds a certain limit level, the detail of the description and the practical value of the information obtained become antagonistic characteristics.

To a certain extent, it is possible to expand the boundaries of the complexity of models and partially overcome the complexity problem by decomposing the complete model into sub-

Scientific Journal of Astana IT University
ISSN (P): 2707-9031 ISSN (E): 2707-904X
VOLUME 9, MARCH 2022

models, the quality of which can be evaluated before including them in the general system. In the end, the smart breakdown of the complete model into components allows you to build a workable system that provides reliable information at an acceptable cost of machine time.

When developing portals, the use of ontological models and functional models to describe the subject area of the systems being developed is becoming more and more relevant.

Literature review

The scientific and methodological foundations of designing information and educational portals are considered in a number of works (Zervas, P., Kardaras, V., Sampson, D.G. [13], Maldonado, U.P.T., Khan, G.F., Moon, J., Rho, J.J. [14] and etc.).

The study of Bayesian networks was conducted by such scientists as D. Pearl, R. Neapolitan, D. Heckerman, F. Jensen, the works of R. Baker, C. Romero [15], S.Ventura [15], E. García [15] are aimed at studying the intellectual analysis of educational data. In most of the works, the scientific and methodological foundations of the design of educational systems are considered.

The issues of automation of education in universities and the construction of a functional model are considered in the works of O. A. Biesterfeld [10], S. V. Cheremnykh [9], I. O. Semenov, V. C. Ruchkin [9]. V. M. Mishin [6,7] devoted their works to the study of issues of improving the organization of university management in market conditions.

Prerequisites for the use of applied tasks based on the semiotic-ontological model of learning are presented in the research of O. M. Toporkova [3]. L. R. Chernyakhovskaya et al. created an ontological model and analyzed e-learning systems [4]. The description of methodological aspects of the learning process and the creation of an ontological model are implemented in the research of the Ufa State Aviation Technical University. The division of ontologies in knowledge portals by topics to improve search efficiency was proposed by O.I. Borovikov [5].

Main part

«An ontology is called a short and visual description of a subject area, which presents all its essential elements (objects, processes, properties, etc.) and the relationships between them» [1].

The problem of classification of elements and relations for the construction of a structural and logical model of the subject area, reflects the dynamic and temporal relationships, is based on the application of the ontological approach, which will allow you to determine the elements (classes, types, attributes, functions) of the components necessary for use in the portal.

Domain ontology contains ontological concepts specific to a particular domain that reflect the essential properties, relationships, and relationships of classes of real-world objects perceived in a given domain. The ontological context defines the ontological binding for the components. The elements of the component specification define the definitions of the domain concepts and the relationships between them [2].

One of the practical approaches to the representation of ontologies is to define them in the form of a dictionary of specific representatives of the categories of concepts of the subject area, the relations between them, and the restrictions imposed on them.

The conceptual basis of the ontological base, with the help of which the semantic independence of information solutions from the features of their system implementation is achieved, consists of the following types of objects:

- terms, facts, their role in reflecting the concepts of the subject area;
- rules, conditions, restrictions that define the relationships of entities;
- functions, methods for identifying and presenting domain entities.

The last listed type of objects, not directly related to the ontological base, is largely determined by the features of the selected system tools, domain models, and syntactic means of describing data. Its inclusion in the structure of the considered types of objects is justified by the desire to maintain the functional completeness of the means of extracting and presenting the properties of the subject area, the object integrity of the problem-oriented application [8].

Thus, the formation of the subject area by defining classes and relations, defining individual representatives of the selected classes and the values of their properties, building a statement about classes and representatives, you can get an ontology of the information structure of the system.

For abstracting any subject area, the categories of «objects» and «relations» between objects are recognized as primary and indivisible, the original data structure - the «object-property» table - is a method that uniquely displays the observed properties.

Formally, the subject area of PO as a system of relations between objects can have the form: PO = {So, Rs}, where So – is the set of PO objects, Rs – is the set of relations between objects (in the analysis, we can limit ourselves to considering binary relations), and $S_0 \neq \emptyset$, $R_s \neq \emptyset$. It is assumed that similar in a sense, the objects form an unusual classes: $S_0 = \cup_{i \in iX} S_i$; $S \cap S_j = \emptyset, i \neq j, i, j \in iX$ - is a non - empty set of indices. Inter-object relationships are manifested in the presence of constant objects (can be intrinsic) properties. The set of all such different properties in the domain is $Pr = \{pr_j\}_{j \in jX}$ where jX - is a non-empty set of indexes. The logical result of this view is the conclusion that the source material for the abstract representation of the subject area is the table «object-property».

By tradition, the rows of the table correspond to the objects that are in the subject area under consideration, the composition of properties - the properties of objects (attributes, relationships, functions, and restrictions).

By defining the above specific representatives of categories in the form of a dictionary of domain concepts, you can build a table of all objects and their properties for the components intended for building the portal.

Functional diagram of the interaction of the subject area is presented in figure 1, provides an opportunity to assess a list of domain objects, their connections and to build the compliance of objects and relations table «object-property» table 1.

Scientific Journal of Astana IT University
ISSN (P): 2707-9031 ISSN (E): 2707-904X
VOLUME 9, MARCH 2022

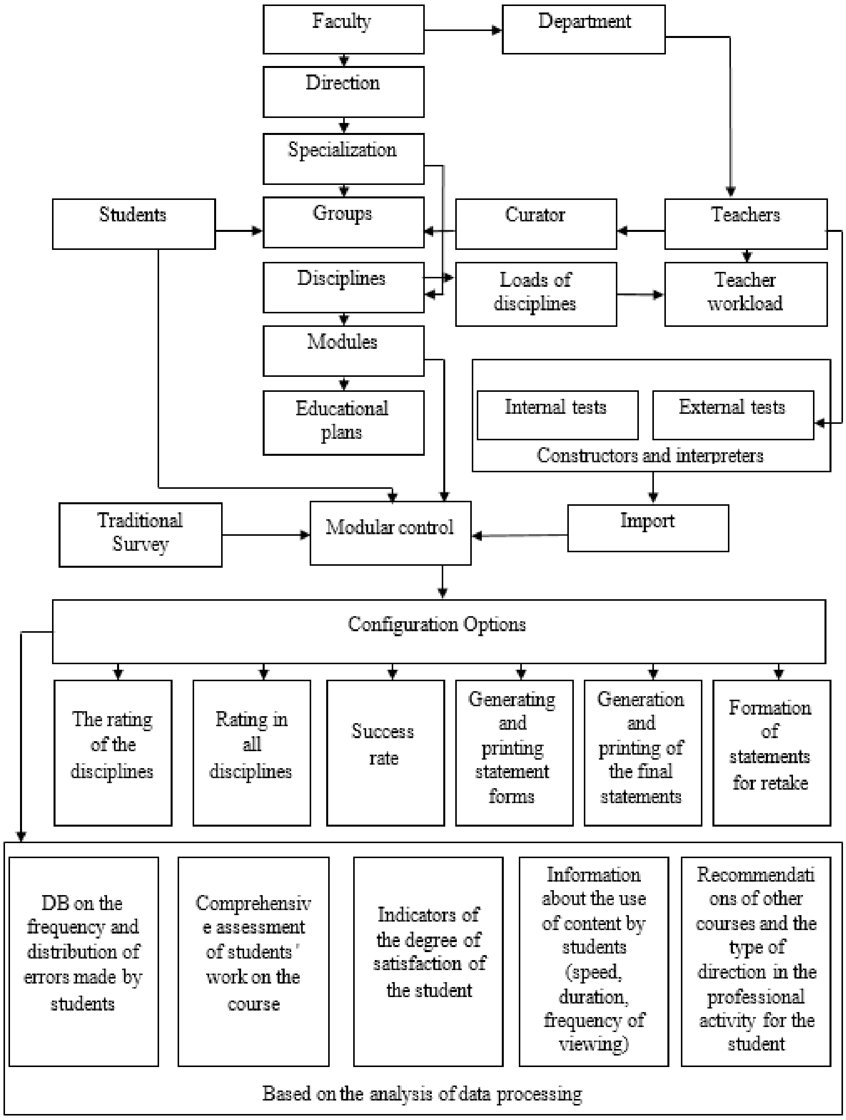

Figure 1. Functional scheme of interaction of objects of the subject area

The term «none» in this table means that there is no relationship between this object and all other objects in the subject area under consideration. The ontological context defines the ontological binding for the components. The " + " symbol indicates the presence of a subset of specific attribute type properties for this object with the entire set of attributes.

A link is any direct connection between the elements of a specification. There are different attribute relationships between an object and its attributes, a reference relationship between two types of objects using a reference attribute, and a type / subtype relationship between a subtype and a supertype.

For example, an attribute relationship indicates the presence of a given attribute in the properties of the object in question, but does not control the uniqueness of its value with other identical data of a particular object; a reference relationship is a relationship between objects that establishes a unique value relationship between them. The concept of an attribute relationship and a reference relationship are defined as follows:

Definition 1. $A \to B$ is an attribute relationship if one of the following cases occurs: B is a simple attribute of type A. Example: «Faculty» → «Name»; type A contains a link attribute b that points to type B, example: «Module» → «Discipline».

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Definition 2. A * B is a reference relationship if A and B are objects that belong to different types. Example: «Success» = «Student» * «Discipline» * «Module» → «Assessment».

Definition 3. A reference relationship is one-way, that is, the A * B relationship does not allow a B * A relationship, the «top-down» hierarchy is always preserved.

Table 1. Correspondences of objects and relations «object-property» table

Properties, relationships \ objects	Level	Object's own index	connection of the i-th object of the 1st order	connection of the i-th object of the 2nd order	Properties of the i-th Prj object
References	1	J={1,2,...n}	none	none	+
Faculties	1	F = {1,2,...k}	none	none	+
Direction	1	D= {1,2,...m}	F[i]	none	+
Departments	1	C= {1,2,...l}	F[i]	none	+
Specialties	1	S= {1,2,...t}	F[i]	D[i]	+
Access	1	A = {1,2,...d}	none	none	+
Personnel	1	K= {1,2,...h}	F[i]	none	+
References	2	Jf={1,2,...n}	J[1]	none	+
Faculties	2	F[i]	none	none	+
Departments	2	C ={1,2,...c}	F[i]	none	+
Direction	2	D ={1,2,...k}	F[i]	none	+
Specialties	2	S={1,2,...t}	F[i]	D[i]	+
Personnel	2	K ={1,2,...h}	F[i]	C[i]	+
Groups	2	G={1,2,...t}	S[i]	none	+
Disciplines	2	L={1,2,...p}	S[i]	none	+
Teachers	2	T ={1,2,...q}	K[i] +L[i]	G[i]	+
Curators	2	P ={1,2,...v}	K[i]	G[i]	+
Students	2	U={1,2,...x}	G[i]	none	+
Access	2	A = {1,2,...d}	F[i]	none	+
Modules	2	M = {1,2,...m}	L[i]	none	+
Success rate	2	R= {1,2,...r}	U[i]	M[i]	+
Tests	2	H= {1,2,...z}	M[i]	none	+
Test results	2	B = {1,2,...b}	U[i]	H[i]	+

The structure of objects and relationships, the functional relationship of which is shown in the diagram, allows us to describe in the above terms the dependencies between objects.

Directories are general-purpose objects that are necessary for assigning attributes to domain objects, along with properties of any other types.

In General, any domain object has a set of necessary for the operation of the attributes, so we can say that: $S_{0_{i\in iS_0}} \to \{pr_j, (pr_j \to J_{m\in mJ})\}_{j\in jP}$, где prj $\mathrm{pr_j} \to J_{m\in mJ}$ - is a directory type attribute.

The reference relationships of first-level objects are defined as follows:

- «Directions»: $D_{j\in jD} \longmapsto F_{i\in iF}$;
- «Departments»: $C_{j\in jC} \longmapsto F_{i\in iF}$;
- «Specialties»: $S_{j\in jS} \longmapsto F_{i\in iF} \longmapsto D_{i\in iD}$;
- «Frames»: $K_{j\in jK} \longmapsto F_{i\in iF}$;
- «Access»: .$A_{j\in jA} \longmapsto F_{i\in iF}$

For the second level, for most of the objects that are represented on the first level, a characteristic reference relationship is a relationship to a certain type of "Faculty" object. Let's

Scientific Journal of Astana IT University
ISSN (P): 2707-9031 ISSN (E): 2707-904X
VOLUME 9, MARCH 2022

define the i-th faculty from the set of objects of this type as $F_{j \in jF} = F_i$, then for all objects in this faculty, the relations will have the form:

- «Directions»: $D_{j \in jD} \longmapsto F_i$;
- «Departments»: $C_{j \in jC} \longmapsto F_i$;
- «Access»: $A_{j \in jA} \longmapsto F_i$;
- «Specialties»: $S_{j \in jS} \longmapsto F_i \longmapsto D_{i \in iD}$;
- «Disciplines»: $L_{j \in jG} \longmapsto S_{j \in jS}$;
- «Frames»: $K_{j \in jS} \longmapsto F_i \longmapsto C_{j \in jC}$;
- «Groups»: $G_{j \in jG} \longmapsto S_{j \in jS}$;
- «Teachers»: $T_{j \in jT} \longmapsto K_{j \in K} \longmapsto L_{j \in jL} \longmapsto G_{j \in jG}$;
- «Curators»: $P_{j \in jP} \longmapsto K_{j \in K} \longmapsto G_{j \in jG}$;
- «Students»: $U_{j \in jU} \longmapsto G_{j \in jG}$;
- «Modules»: $M_{j \in jM} \longmapsto L_{j \in jL}$;
- «Success»: $R_{j \in jR} \longmapsto U_{j \in U} \longmapsto M_{j \in jM}$;
- «Tests»: $H_{j \in jH} \longmapsto M_{j \in jM}$;
- «Test Results»: $B_{j \in jB} \longmapsto U_{j \in U} \longmapsto H_{j \in jH}$.

Structural relationships are manifested in the presence of reference-type properties in the objects of the subject area. The values of such properties are a reference to existing objects.

Introduced additions to the accepted understanding of the stage of formation data about the subject give the opportunity by simple transformation of the table «object-property» select object classes reflecting the heterogeneity of these objects and the composition properties and ability to engage in structural relationships.

If you replace the «none» value with «0» for the «object-property» table, and the other values with «1», then the original table is transformed into the «object-property» incident matrix contained in it, which is sufficient to build a conceptual model of the subject area. The algorithm proposed for this purpose in [2] is based mainly on adding and removing certain rows and columns in the matrix to achieve the following goals:

- allocation of object classes by storing one instance of each set of matching strings;
- exclusion of invalid attributes from the model (removal of «null» columns);
- statement of the class of unidentified objects of the attribute type (respectively, adding a new column);
- a statement of the existence of some special class of unidentified objects (according to the addition of a new specially constructed string).

As a result, we get an incident matrix with dimension m*n, 1⩽m⩽r+a, 1⩽n⩽s+k, which determines the correspondence ICl*A, where Cl - is the set of identified object classes (primary concepts in the domain specifications); A is the set of features corresponding to the components (attributes), it is obvious that . Thus, the classification is embodied in the presence of i in the composition of Cl, the associations of objects of the subject area are reflected by the semantics of sawdust A.

If everything is clear with the functional scheme, then most of the questions arise to the functional model. It is proved that increasing the efficiency of management, fast and high-quality solution of complex management tasks, as well as the implementation of management measures requires the availability of operational information. The reliability and timeliness of such information depends on its sources, the purity and order of information flows. The allocation and ordering of information flows at the university is possible with the help of IDEF technologies. They allow the activities of any subject to be decomposed into processes, subprocesses and actions, which further provide an opportunity to identify information flows and use them in the management of the university.

We will be able to implement a functional model using IDEF technologies, namely, the methodology of functional modeling IDEF0, which is the basis of block modeling. Any functional model in the MS VISIO environment starts with a diagram that has only one active block, which is further decomposed (Figure 2).

We have already determined that the desired result in the university's activities is achieved more effectively when activities and related resources are managed as processes. By the process itself, we mean any activity or set of activities during the course of which the resources necessary to transform the "input" into the "output" are used.

First of all, let's define all the mandatory elements of the diagram. It has a special kind of Diagram A0, which consists of one block describing the top-level function "To provide an educational service", its "input", "output", "management" and "mechanism". In our case, at the "entrance" there is an applicant and the information that accompanies him, at the "exit" there is a graduate. the diagram of the functional model "To provide an educational service" is decomposed into four functions-components describing the process of providing educational services, namely: to manage the educational process, to accept for training, to teach according to the educational program and to certify. Such a diagram has the status A0 (Figure 3).

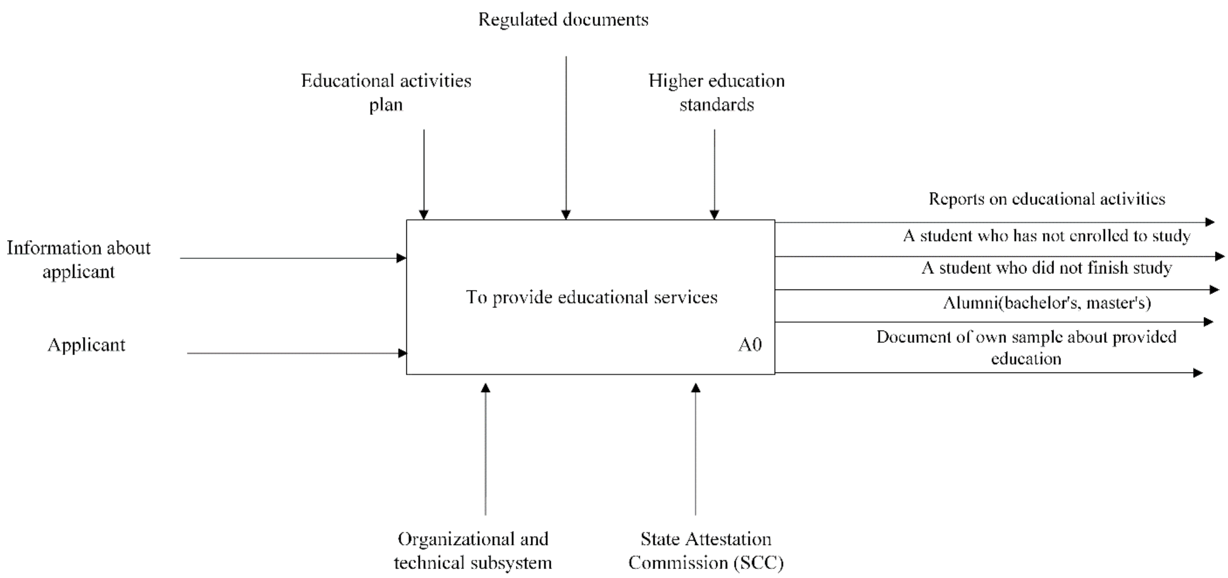

Figure 2. Diagram of the functional model of the provision of educational services by the university

At the level of this diagram, the controls and mechanisms have not changed, only they are detailed with respect to each process, so:

- for the A1 block "Management of the educational process" - the management is higher education standards and the educational activity plan, regulatory documents, the mechanism is an organizational and technical subsystem, which includes: the educational and methodological department, the admissions committee, faculties, departments and the information and analytical management system of the university (IASUM);
- for the A2 block "Accept for training" - the admission rules and procedures, the admission plan and internal regulations documents act as the management, the mechanism is the admissions committee, IASUM;
- for the A3 block "Training according to the educational program", the management is higher education standards, working curricula, lesson schedules, the mechanism is the dean's office, faculties, the teaching staff, IASUM;

Scientific Journal of Astana IT University
ISSN (P): 2707-9031 ISSN (E): 2707-904X
VOLUME 9, MARCH 2022

- for block A4 "Attestation" - the management is the quality standards of education, the working curriculum and regulatory documents, the mechanism is the State Attestation Commission (SAC), IASUM.

The mechanisms behind each component function have their own powers, which are fixed by the University Charter. It should be noted that at the output of the diagram, we do not always unambiguously get a graduate, because not all students: firstly, can complete a theoretical course of study; secondly, not all students can pass certification; thirdly, some students have the right to be expelled at their own will, even without completing a theoretical course of study.

At the A0 level of the functional model, as a result of the transformation, such information flows arise as: reports of various kinds on educational activities, information about various categories of students: those who have been accepted for study, who have not completed a theoretical course of study, those who have not completed a theoretical course of study, those who have not completed their studies, and those students who have not passed the certification.

Thus, based on the developed functional model, we formalized all the hidden information flows that are the result of relationships and relationships between processes, subprocesses, operations and actions, most of these connections turn out to be the power of abstraction during the movement of information flows.

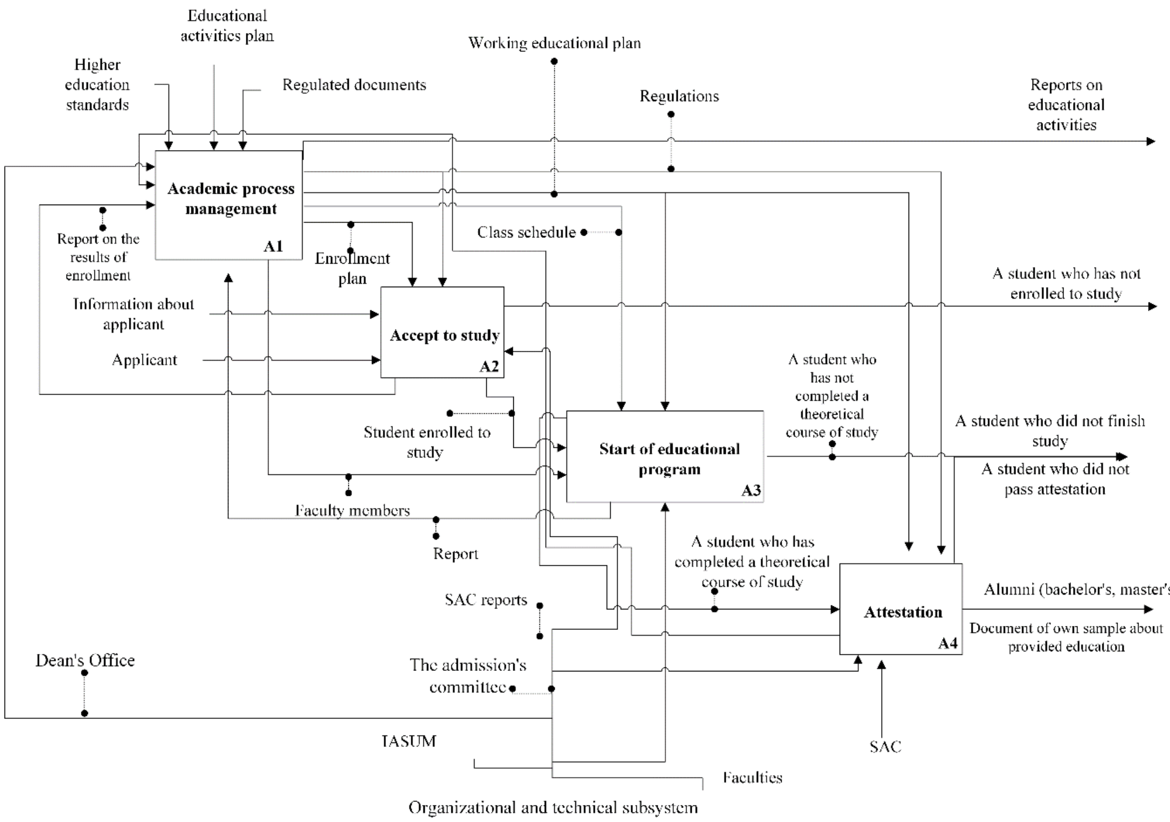

Figure 3. Decomposition of the functional model of the provision of educational services by the university

Conclusion

The considered forms of abstraction are the basis of the relational approach in modeling databases in practice. The ontological approach further updates the generalization abstraction, in which similar classes are associated with a higher-level parent object. In this case, the domain ontology is represented as a model that describes the structure of classes (both real ones defined in the domain model, and abstract ones obtained by generalizing the specifications of real classes).

Given the sufficient variation in the choice of accepted properties of the domain, we can assert a plurality of domain ontologies that describe the same real classes of objects in different ways and therefore differ in concepts, generalize, and take into account relationships. The result of the ontological analysis is a conceptual model that describes the structure of the database classes.

The effectiveness of the ontological analysis is more full-on available data on the subject area and the formal-algorithmic nature of the transformation of the conceptual object-attribute models in the domain ontology.

Based on the proposed ontological model developed by databases of the information-educational portal of the University and defines the classes and properties to implement this model.

And also, on the basis of the result on the formalization of all hidden information flows, an information and analytical management system of the university has been developed, which is:

- a comprehensive system that covers all types of university activities, integrates all information flows and forms a single information space;
- provides for a gradual transition to international standards of the management structure, preservation and exchange of information and the formation of a unified regulatory framework;
- does not contradict the technologies that are used at a certain point in time, taking into account the existing organizational structure and forms of management;
- it is flexible to settings both before changes in the legislation of the Republic of Kazakhstan and international and provides for the possibility of expanding and increasing functions through the development of new modules;
- it is a shell of the unified information space of the university.

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