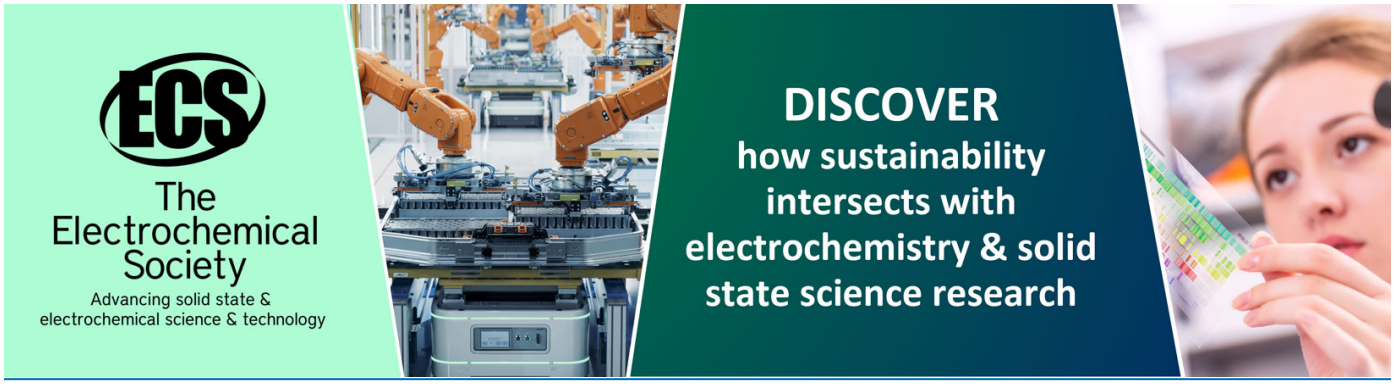
Ontological Model of Agro-Industrial Complex of the Region



Ontological Model of Agro-Industrial Complex of the Region

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Abstract. The paper presents the results of making an ontological model of agro-industrial complex management. The purpose of ontological modeling is to describe the subject area to develop a digital platform for agro-industrial complex management. The hierarchy of the ontological model of the agro-industrial complex management in the region is presented, in which the meta-level, ontologies of the upper and applied levels are identified. A concept map of the agro-industrial complex was developed, which allowed to define the industry concepts and relations between them. A general ontology of industry management is formed with subjects and objects of management, their attributes, relations and axioms identified as structure-forming elements; among ontological coordinates there are space, time, an ontological classifier and naming technology. The article presents results of testing the ontological management model using the case of the agro-industrial complex in the Republic of Bashkortostan.

1. Introduction

The article is part of the research on the design of a digital information and communication platform for strategic management of the agro-industrial complex of the region [1].

An industry digital platform is inherently the industry's digital twin. As it is now being implemented in the agricultural sector of Russia, it is at an initial stage characterized by the presence of a dozen software products and web resources aimed at performing separate management functions in the industry [2-4]. The target indicators under the *Digital Economy of the Russian Federation* Programme [5], as well as the fact that the agricultural industry is located on the outskirts of the Russian *digital funnel* [6] testify to the need to develop a digital platform.

In some cases, however, a cross-cutting platform may have a greater practical effect. In particular, communication tasks of the subjects of the agro-industrial complex activity can be better solved by developing a cross-cutting platform.

The agro-industrial complex is a collection of branches of the economy producing and processing agricultural raw materials (Figure 1).

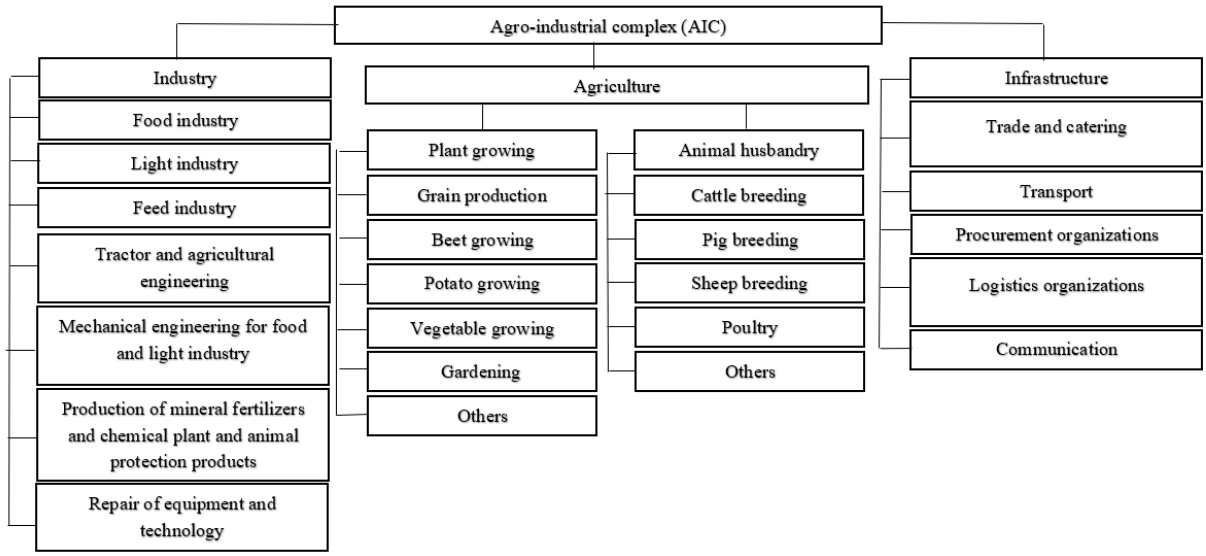

Figure 1. Industrial complex by industries.

This special feature complicates the task of creating a digital twin of the AIC. In this case, there are two ways to go: to make and adopt digital platforms for agriculture, mechanical engineering, food processing, transportation, and so on; and then to integrate individual blocks of the listed platforms based on the goals and objectives of the AIC. But this way is long and more labor-intensive, and it makes the prospect of digitalizing the AIC more distant. The AIC will remain on the outskirts of the *digital funnel*. The second way is to immediately organize an independent digital platform of the AIC and in parallel to integrate it with the *digital twins* of related industries [7]. In addition to addressing a number of AIC issues, such a platform would have even greater network impact than the digital platforms of the selected industries above.

2. Hierarchy of ontological management models

In the hierarchy of ontological models, the industry model of the AIC management in the Republic of Bashkortostan belongs to the level of applied ontologies (Figure 2).

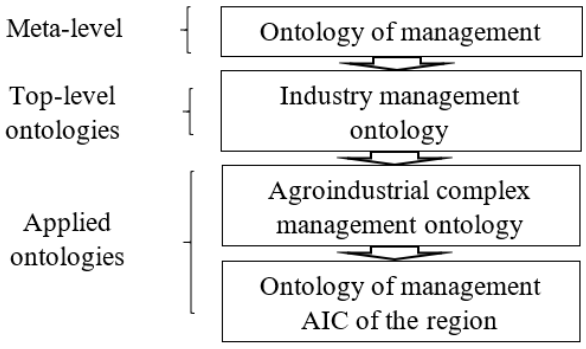

Figure 2. Levels of the region's AIC management ontological model.

In turn, at the meta-level, the AIC model is based on ontologies of the animal world, the plant world; the upper level is based on models of the industries that make up the AIC and have their *projections* on the AIC ontology. The AIC management ontology can be projected into the depth of applied ontologies on the plane of other subject areas, for example, the ontologies of AIC logistics, AIC funding, AIC innovative development, AIC digitalization, etc.

Clarify one thing here. As is known [8], there are ontologies of the subject area and ontologies of processes (tasks). In this paper, the AIC management ontology will refer to the subject area ontology (despite the term *management* in the title) and describe static data and knowledge about the AIC. Dynamic processes that directly reflect various aspects and results of AIC management will be reflected at the next stages of modeling: a cognitive map of AIC management and an AIC business process model. The ontological model of the subject area of AIC management will allow to unambiguously define concepts as subjects and objects of management reflecting the main purpose of the digital platform as a tool of *soft* management of the industry.

3. Formation of a concept map of the agro-industrial complex

The preliminary stage for the formation of an ontological model for the industry was the creation of a concept map (CMAP) of the AIC, which, on the same basis as a dictionary, thesaurus and taxonomy, belongs to the category of *light* ontologies (Figure 3) [9]. The concept map operates with notions such as concepts and arbitrary relations between them. The AIC CMAP has allowed to define the basic classes (concepts) of the AIC and relationships.

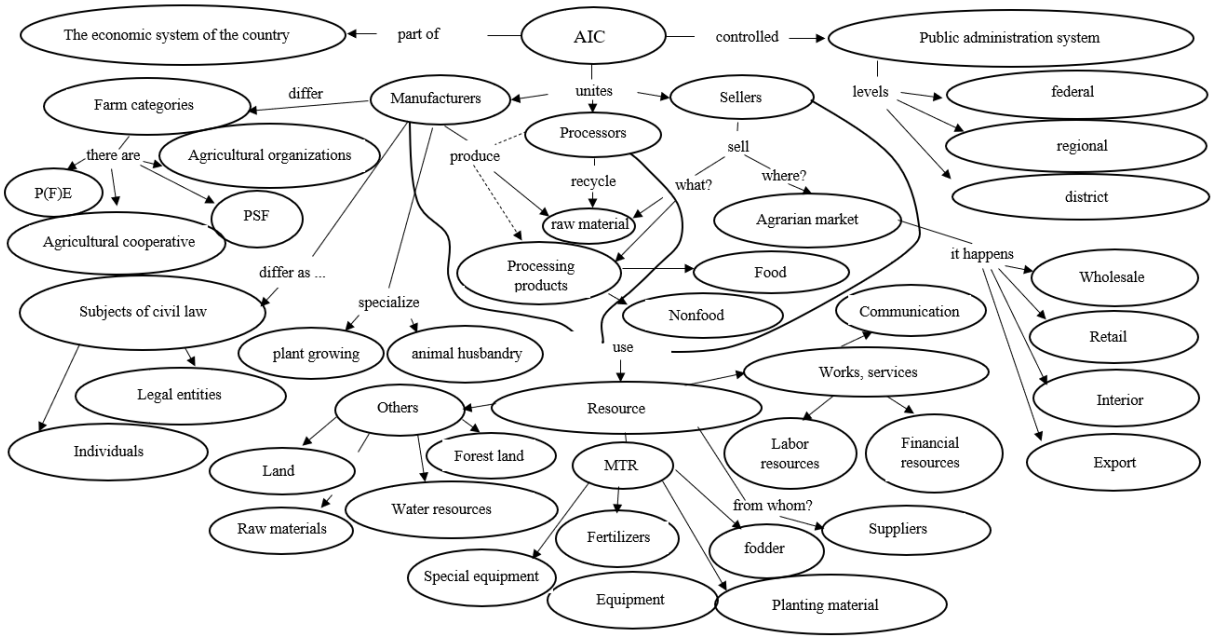

Figure 3. Concept map of the agro-industrial complex.

4. Ontological model of agro-industrial complex management in general form

A general scheme of ontological model of agro-industrial complex management (Figure 4) has been developed.

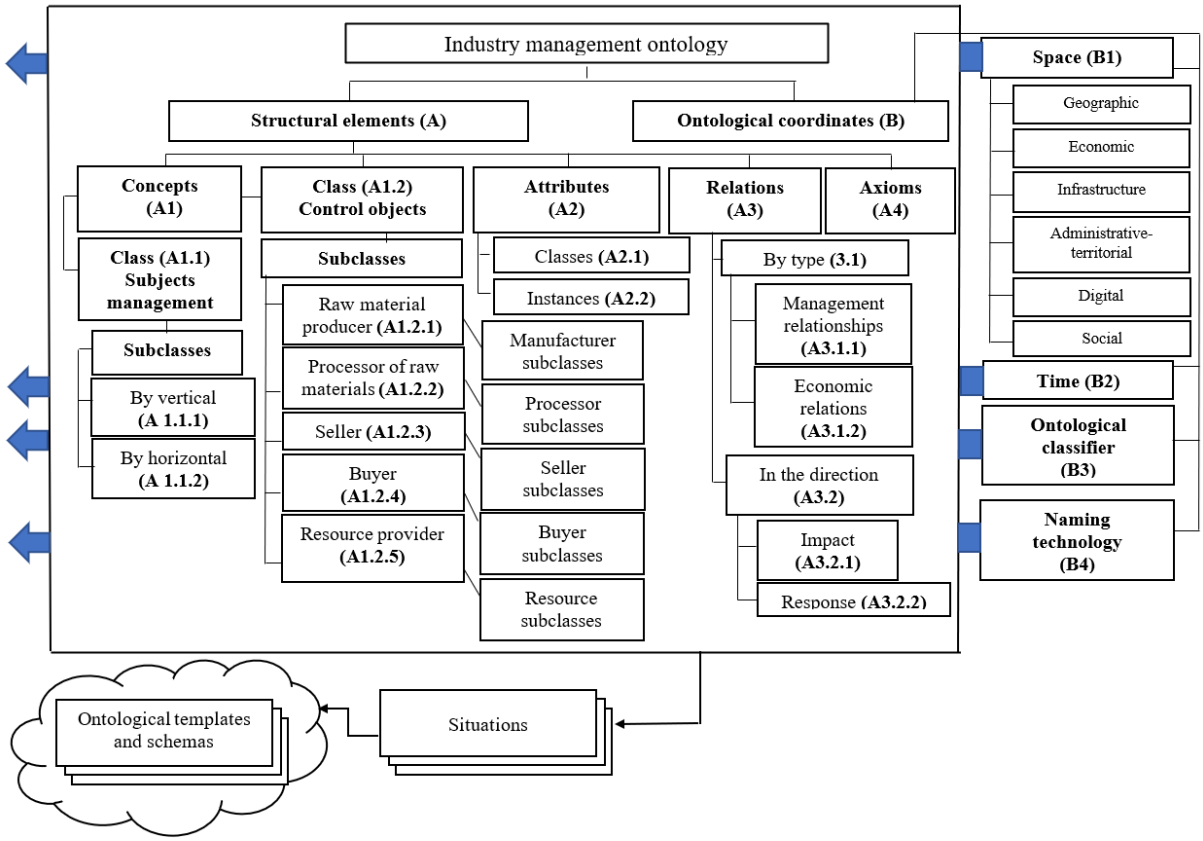

Figure 4. Industry management ontology.

Ontology operates with notions such as concepts (classes), attributes (properties of concepts), relationships and axioms. The model is based on a general ontology construction methodology set out in the works of foreign [10-14] and Russian scientists [15-16], as well as approaches to business system ontology reflection proposed in papers [17,18].

5. Testing the developed AIC ontology for the Republic of Bashkortostan

The Republic of Bashkortostan is one of the major agricultural and industrial subjects of the Russian Federation. According to the data on 2019, the Republic of Bashkortostan came 8th in the production of agricultural products and was among the five leaders in the production of honey (1st), milk (2nd), cattle (2nd), horse livestock (2nd) and potato production (4th). Development and implementation of such a digital platform in the information infrastructure of the agro-industrial complex of the RB will allow to increase the efficiency of interaction between economic subjects of the industry, between subjects and objects of management, to enter new markets, which will eventually increase the competitiveness of the industry, improve the economic, social and demographic situation in rural areas of the republic.

In this article, in view of the limitations on the volume of publication, concepts are described only in terms of the subclass of management subjects.

Table 1 describes the subclasses, attributes and examples of the instances of management subjects for the management ontological model of the agro-industrial complex of the Republic of Bashkortostan.

Management subjects include two subclasses: the ones on the vertical axis reflect the vertical of the government's management structures, to which lower management levels are subject, and management objects (macro- and meso- management levels). The macro level is a federal one, the mesolevel is a regional (subjects of the Russian Federation) and a district (municipal districts) ones. When making an AIC management ontological model for the purpose of designing a digital industry

platform on the regional level, we consider it impractical to include macro-level concepts (the Government of the Russian Federation, the Ministry of Economic Development of the Russian Federation, the Ministry of Finance of the Russian Federation).

The management subjects on the horizontal axis are a set of interdepartmental structures under ministries, as well as the authorities of municipal districts.

Attributes are reflected in two perspectives, namely both concept characteristics and concept relationship characteristics [19].

Table 1. Ontological characteristics of management subjects.

ID	Subclass	Relationship	Subclass attributes	Specimens	Specimen attributes
1.1.1	Control effect on management objects (direct, indirect methods of management) is part of management subjects;		Regional Ministry of Agriculture of the Republic of Bashkortostan; Ministry of Industry, Energy and Innovation of the Republic of Bashkortostan; Ministry of Digital Development of the State Administration of the Republic of Bashkortostan; Ministry of Trade and Services of the Republic of Bashkortostan		Strategies, development programmes; Management object support programmes; Support programmes for management subjects
1.1.2	Municipal entities	subordination to the authorities of the republic (linear); subordination to the ministry of agriculture of the republic (functional)	is part of management subjects; district	Authorities of the municipal districts of the Republic of Bashkortostan (Abzelilovsky, Alsheevsky, Arkhangelsk, Askinsky, Aurgazinsky and others, 54 in total).	Population; geographical location; gross regional product; basic equipment stock; agricultural land; crop areas; crop yield; livestock; poultry

Axioms for the *Management Subjects* subclass:

1) The Ministry of Agriculture of the Republic of Bashkortostan applies direct and indirect management methods (macro- and micro-economic impact) with relation to management objects, the other ministries use only indirect methods (macroeconomic impact);

2) The concept of *Municipalities* includes only municipal districts (does not include urban districts).

In addition to the structural elements in the ontology there are ontological coordinates.

The ontology of space describes the spatial coordinates for the ontological model, limits the activity of the concepts of ontology in space (forms natural and conventional boundaries). Natural ontological boundaries describe geographical space. For the AIC management ontology of the Republic of Bashkortostan, geographical boundaries determine the economic expediency of physical movement of individual production resources (for example, hiring, leasing of special equipment and agricultural machinery) and markets for the sale of finished products. Geographical space is static and has quantitative characteristics.

The economic space of the model is determined by the economic ties and relations between the Republic of Bashkortostan and the Russian Federation as a whole. Economic space is dynamic, can expand and narrow borders over time and it also has quantitative characteristics.

The AIC efficiency depends on the quality of the infrastructure space. This category includes road transport infrastructure, engineering infrastructure (development of water supply, sewerage, heat supply, waste management, gasification, continuity and sufficiency of power supply, communication development). Infrastructure space is dynamic (improvement and deterioration of infrastructure) and has qualitative and quantitative characteristics.

Economic, administrative-territorial, infrastructure and digital spaces create conventional (artificial) boundaries of the ontological model.

The identification of a category of administrative-territorial space for the AIC management ontology reflects special features of the industry management ontology. In particular, one of the attributes of a management object is belonging to an administrative-territorial unit, namely a municipal district. The category is static and has quantitative characteristics.

The identification of digital space is the author's idea. It should be distinguished from a presence or an absence of Internet communication in the area (this factor refers to factors of infrastructure space). It is more of a qualitative indicator that demonstrates whether there is a digital environment, how well it is used, how it is applied in manufacturing, distribution chains and technology management of Industry 4.0, whether there are more industry professionals in those activities where personal attendance is not obligatory (consulting, training), how management entities in the industry are involved in events in a remote format, etc.

Social space has quantitative characteristics, it is dynamic. Indicators characterize demographic aspects of a simulated ontology, social objects, standard of living.

The ontological coordinate *time*, on the one hand, is closely related to space (the term of ontological modeling *space-time volume*), so based on the listed spatial coordinates, it is obvious that the most acceptable time interval to capture the main parameters of the ontological model of the industry is a calendar year (at the end of the calendar year). On the other hand, for management objects as economic entities, another unit is more acceptable, namely the financial year. From the perspective of industry management there are three horizons of planning and forecasting: strategic planning (10-20 years), tactical planning (3-5 years), and operational planning (1 year).

6. Conclusions

The ontological model of AIC management presented in the article was designed by the authors from the position *as is* on the basis of knowledge about the subject area from open sources, publications by industry specialists [20, 21] and their own practical experience. The next step in design will be to build a cognitive model aimed at modeling the control impacts directed at moving the industry from its current state of *as is* to its target state of *as should be*.

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Acknowledgments

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