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HYBRID INTELLIGENT SYSTEMS AND MODELS FOR ARCHITECTURAL DESIGN OF MANAGEMENT SYSTEM

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Abstract

This paper deals with the issues of Russian and international researches in the field of design of information architecture of management systems in the context of spatial economics. At present modern intelligent methods and technologies are essential components for developing management decision process that will enable companies to succeed in a rapidly changing environment. The latest achievements in the field of intelligent technologies in economy and management, including the methods and tools of soft computing are the key factors in improving organizational performance and increasing its competitiveness. The paper is devoted to the study of issues of hybrid intelligent systems and models application to architectural design of management information systems (IS). Fuzzy technologies as technologies of artificial intelligence are having a significant influence on information systems design and analysis. Simultaneously information systems sustainability and adaptiveness are now one of the main drivers of business success. Original contribution of the work is based on the applying of intelligent information technologies and modern modeling methods for creating scoring model of information systems sustainability. It is theoretical and empirical research in equal measure. Research methodology is methods and procedures of modeling.

The main purpose of this paper is consideration the features of application of contemporary hybrid intelligent systems and models for spatiotemporal analysis. The paper also contains theoretical foundations of information systems architecture and the brief overview of spatial sciences development in Russia. It does so from a research base that draws from theoretical underpinnings as well as international and domestic industry practices.

Keywords: Hybrid Intelligent Systems and Models, Spatial Economics, Fuzzy Logic, Architecture of Management Information System

INTRODUCTION

Nowadays, the combination of different approaches, styles, and paradigms for building of the most appropriate and efficient single hybrid model is one of the effective methods for use of intellectual tools for solving management problems. One of the examples of this approach is the development of model for the study of such important characteristics of management systems as sustainability and adaptability of their information architecture in the context of spatial economics.

Architecture of management information system can be considered as a concept, which determines the model, the structure, functions and components' relationship.The term "Enterprise architecture" is usually used concerning organizations and as shown in Figure 1, the next main types of architectures are assigned [1]:

- Business architecture,
- Information technologies architecture,
- Data architecture,
- Application architecture or Software architecture, and
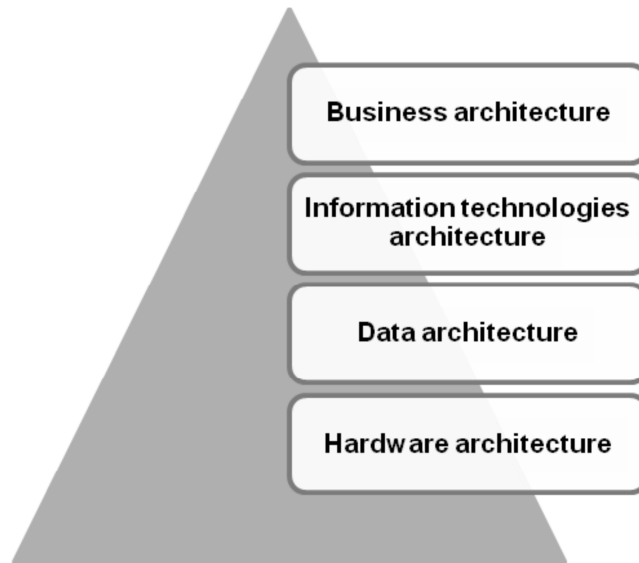- Hardware architecture.

Figure 1: Information system architecture

Typically, information systems are focused on the use and satisfaction of customers' needs within a specific subject area. As examples of information systems application for solving problems in economics and management can be specified as the following:

- Enterprise management information systems,
- Trading information systems,
- Marketing information systems,
- Geographic information systems,
- Health care information systems, etc.

Sustainability of architecture of information system is determined by the stability of its structure, state parameters, and the most important is the stability of the current processes of its functioning and development. Adaptability of information system first of all means its flexibility and property of adjusting itself under varying changes. Adaptive architecture of information system is a methodology to create a more flexible and rational, customizable architecture that allows organizations of any size to react promptly to market and information flow changes. Design of sustainable and adaptive architecture of information systems is possible based on the development of hybrid intelligent model and applying of such intelligence information technologies as neural networks and fuzzy logic.

MANAGEMENT SYSTEMS AND INFLUENCE OF SPATIAL FACTOR

Spatial science, as an area of interdisciplinary scientific research, has become especially popular in the last decades. Attention of many scientists, including researchers in the field of spatial sciences, in particular, spatial economics, more and more focuses on the study of such important elements in formation of spatial relationships, as information infrastructure and architecture of spatial information systems. Great importance, both in Russia and in the other countries, is given to the development of global, regional and national spatial data infrastructure. The most important initiatives in this direction are the existing international programs: Infrastructure for Spatial Information in Europe, National Spatial Data Infrastructure, Global Spatial Data Infrastructure, and Global Monitoring for Environment and Security. What is important concerning Russia is, that the general architecture has created and the main components of the Russian segment of the information infrastructure and its integration into the world system have defined. The concept and theory of the "economic space" was formed in compliance with geographic, geopolitical, and regional concepts. And now an economic space is considered in the framework of concepts of globalization, industrial spatial clusters, "cumulative causation", high information technologies and network. Analysis of points of view on the economic space can be divided into four approaches to the study of this category: territorial, resources, information and process. The territorial approach has long dominated over the other approaches. The essence of this approach is based on economic space as a saturated territory having a plurality objects and the relationships between them. Resource-based approach determines the economic space as an environment for decision making about use of resources. The essence of the information approach is that economic space is considered as the information component of the economic process. Information approach adequately reflects the role and importance of information exchange between business entities. Process-based approach gives reason to determine the economic space as a relationship between economic processes of business entities and aggregate economic process with the purpose of formation of the possible outcomes of economic activity. Adding the marketing function to the structure of the functions of economic space is dictated by the need to replicate the economic space in time under the influence of scientific and technological progress, innovation, transformations in the environment due to the constant changes in requirements and fluctuations of supply and demand [2].

The major advantage of the spatial approach is the ability of multidimensional representation of spatially localized complex systems, in which the economic, ecological, social, geographical, political, and technological components interact. These components determine the functioning equilibrium and development of the region, as well as creating conditions to maximize region's contribution to the spatial systems development of higher level. The basis of the spatiotemporal concept to management is the principle of systemic approach and consideration of management system as a large complex system consisting of elements of different types and having heterogeneous relationships between them. Spatial system of management is treated as a complex system, a set of subsystems and their relations in many dimensions: social, industrial, territorial, etc.

HYBRID INTELLIGENT MODELS FOR MARKETING SPATIAL RESEARCH

Modern modeling tools should facilitate mutual understanding at different organizational levels when making strategic management decisions thus bridging the gaps between a strategic vision and its implementation [3]. One approach involves multi-agent systems (MAS) which, as a class, have developed rapidly over the last decade. The advantage of a multi-agent approach relates to the economic mechanisms of self-organization and evolution that become powerful efficiency drivers and contribute to enterprise's development and prosperity. New intellectual data analysis can be created, through MAS which is open, aimed at flexibly adaptive problems solving, and deeply integrated in decision support systems [4]. Modern business modeling tools use special software, programming languages and systems to develop models of business processes, relations between people and areas for optimization in the organizational structure as a whole. Building a sustainable and adaptive architecture of spatial information systems is possible on based of the applying of modern modeling methods and technologies [5]. Interdisciplinarity of spatial marketing researches consists not only in expanding the subject of research (joint study of the spaces of different types), but in the synthesis of notions, concepts and methodologies of the social, humanitarian, sociological and engineering sciences, modelling and prediction of interaction and mutual influence of different kinds spaces, a generalization of the theoretical results and creating of the interdisciplinary databases. Definition of qualitative parameters that impact on the equilibrium of operation and development of spatial marketing system and formation of conditions for maximizing its effectiveness entails consideration of four main groups of factors: market, macroeconomic, industrial, and social and technological

(Table 1). The decision of such multicriterion tasks involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. All of these types of systems are not mutually exclusive. Moreover, there are systems that contain all three elements - optimization, simulation and fuzzy inference system.

Table 1. The main groups of factors and indicators

Factors	Indicators
Market	Market segments
	Needs and demands
	Market issues (forces)
	Switching cost
	Revenue attractiveness
Macroeconomic	Economic infrastructure
	Commodities and other resources
	Capital market
	Global market condition
Industry	Competitors
	New entrants
	Stakeholders
	Suppliers
	Substitute products and services
Society and technologies	Societal and cultural trends
	Socioeconomic trends
	Technology trends
	Regulatory trends

Design of sustainable and adaptive information architecture of spatial marketing systems is possible based on the applying of such intelligence information technologies as neural networks (NN) and fuzzy logic (FL) [5]. NN and FL - are methods related to Soft Computing. It is noteworthy that Fuzzy Logic is now considered an essential feature of decision making in companies that actively employ modern information technologies. Applying the information and communication technologies, which are used in soft computing, allows achieving the quantitative results, which is very important for manager to make a decision. Fuzzy set was introduced by Lotfi A. Zadeh [6] as a means of representing data that was neither precise nor complete. There are two main characteristics of fuzzy systems that give better performance for specific applications: the first is that fuzzy systems are suitable for uncertain or approximate reasoning and the second is that fuzzy

logic allows problem solving and decision making on the basis of incomplete or uncertain information. Fuzzy technologies as technologies of artificial intelligence are now having a significant influence on information systems design and analysis [7], [8], [9]. Fuzzy logic models employ fuzzy sets to handle and describe imprecise and complex phenomena and use logic operations to find a solution. A block diagram of Fuzzy logic model is represented in Figure 2.
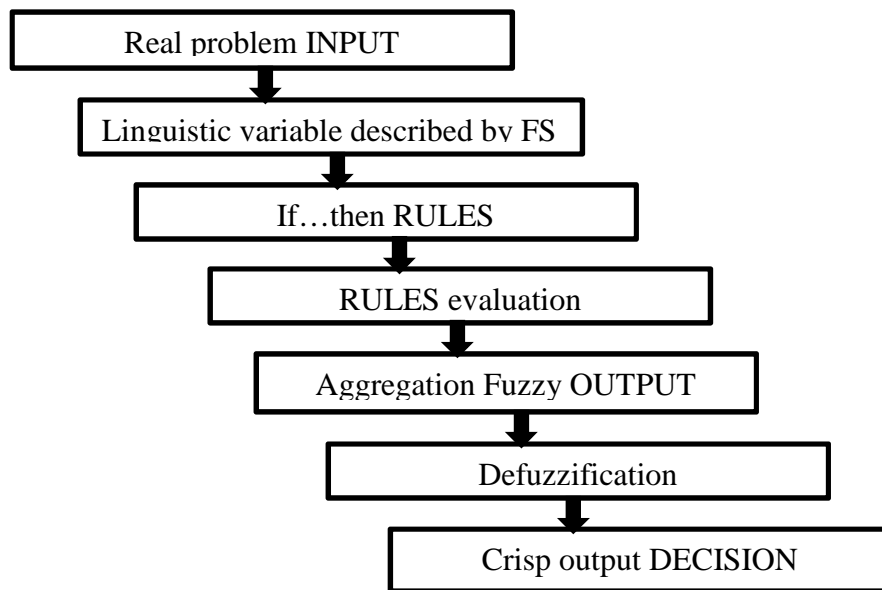
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┌─────────────────────────────────┐
│      Real problem INPUT          │
└─────────────────────────────────┘
        │
        ▼
┌─────────────────────────────────────┐
│  Linguistic variable described by FS  │
└─────────────────────────────────────┘
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┌─────────────────────────────────────┐
│         If…then RULES                │
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┌─────────────────────────────────────┐
│        RULES evaluation              │
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│     Aggregation Fuzzy OUTPUT         │
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┌─────────────────────────────────────┐
│          Defuzzification             │
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┌─────────────────────────────────────┐
│     Crisp output DECISION            │
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Figure 2: FL model block diagram

The scoring model of marketing spatial information system sustainability was described in the paper [5]. This model was developed with the purpose of assessment of product diffusion system sustainability. All calculations were performed in MATLAB v. 7.01. In the first step all input variables were modeled by Monte-Carlo method. In the second step the modeled inputs were introduced into the fuzzy inherence system (FIS) and the values of IS sustainability were formed as outputs of the FIS. The fuzzy approach for assessing of IS sustainability was supplemented by the regression equation in conclusion.

CONCLUSION

System researches of marketing space, the use of spatial approach and multidimensional representation of spatially localized complex management systems may be based on the analysis of four main groups of factors: market;

macroeconomic; industrial; social and technological. The decision of such multicriterion problems involves the use of problem-oriented interactive systems that combine the advantages of simulation, optimization and expert systems. Determination of the parameters that impact on the sustained development and operation of the spatial marketing system and creation of conditions for maximizing of its effectiveness is possible by using hybrid intelligent models and systems.

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