Proceedings of the
8th European Conference on IS Management and Evaluation

University of Ghent, Belgium

11-12 September 2014

Edited by

Jan Devos and Steven De Haes

A conference managed by ACPI, UK

The Proceedings of The
8th European Conference on
IS Management and Evaluation
ECIME 2014

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Jan Devos
Ghent University
and
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University of Antwerp
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Belgium

Papers have been double-blind peer reviewed before final submission to the conference. Initially, paper abstracts were read and selected by the conference panel for submission as possible papers for the conference.

Many thanks to the reviewers who helped ensure the quality of the full papers.

These Conference Proceedings have been submitted to Thomson ISI for indexing. Please note that the process of indexing can take up to a year to complete.

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E-Book ISBN: 978-1-910309-43-8
E-Book ISSN: 2048-8920
Book version ISBN: 978-1-910309-41-4
Book Version ISSN: 2048-8912
CD Version ISBN: 978-1-910309-42-1
CD Version ISSN: 2048-979X

Published by Academic Conferences and Publishing International Limited
Reading
UK
44-118-972-4148
www.academic-publishing.org

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Biographies

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Geert Poels is a full professor of Management Information Systems in the Department of Management Information Science and Operations Management of the Faculty of Economics and Business Administration of Ghent University. He is director of the Information and Knowledge Management research group where he supervises about ten doctoral students. The main research lines of this group are: business process management; enterprise modeling, architecture, and engineering; service science; data mining and business intelligence. Geert Poels holds a doctoral degree in applied economic sciences from the Katholieke Universiteit Leuven. He was a post-doctoral fellow of the Fund for Scientific Research, a lecturer at the former Vlekho Business School in Brussels, and since 2002 he has held professor positions at Ghent University. He has published widely in international academic journals on topics like definition and validation of software metrics, functional size measurement of software, quality in conceptual modeling, and ontology-based conceptual modeling patterns. His current research interests are conceptual modeling of service systems and service-oriented business architecture modeling. In 2012 he was chairman of the sixth International IFIP Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS).

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Jan Devos, PhD, is currently professor in Information Systems, IT Security and IT Trends at the Ghent University. He holds a master degree in Engineering, Computer Science and Applied Mathematics (Katholieke Universiteit Leuven) and an MBA (Vlerick Leuven Gent Management School). His current research interests are IT Governance in SME's, IT/IS failures, IT Trends and IT Security. He has published several peer-reviewed articles on IT and SMEs and is often a speaker at international academic and business conferences. He was co-author of the Cobit QuickStart methodology and editor of a recent contributed volume on IT and SMEs. Jan Devos is a member of ACM, AIS, and is co-chair and country representative (Belgium) for IFIP TC8.

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Hans Van Der Heijden is a Professor of Accounting at the University of Sussex. He holds a Ph.D. in Business Management from Erasmus University Rotterdam, and have previously worked in the Netherlands, Denmark, Ireland and the UK. Before his academic career he worked as a consultant for a Big 4 accountancy firm, specialising in accounting and information systems. He is SAP certified (TERP10). Hans's research interests are at the intersection of accounting and information systems. In particular he studies the design and presentation of complex enterprise data for better decision making. He develops tailor-made software prototypes for this purpose, which collects and enhance the data stored in large complex enterprise systems such as SAP and Sage. He has been a member of, and an advisor to, several professorial selection committees in the UK, Ireland, and Finland and is currently an external examiner at Manchester Business School.

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Elena Serova is an Associate Professor and works at the International School of Economics and Politics, High Economics School, Marketing Dept. St. Petersburg State University of Economics. Her role combines teaching and research and her current research interests are related to Information Systems, Information Management, Information and Communication Technologies, Marketing and Business Models. She has co-authored a book and contributed chapters to several books and collections of essays, she is a regular key presenter at national and international conferences and workshops. As a research active academic with a number of PhD Students under her supervision, Elena is focusing on Complex Information Systems Modelling, Marketing Information Systems, and Business Models in a Global Environment.

Scoring Model of Information Systems Sustainability

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Abstract: This paper deals with the issues of Russian and international researches in the field of design of sustainable information architecture of management systems in the context of spatial economics. 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 intelligent information technologies and systems for spatiotemporal analysis. The paper is devoted to the study of issues of stability of architecture of spatial information system. Now 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 agent-based modeling and soft computing are the key factors in improving organizational performance and increasing its competitiveness. Fuzzy technologies as technologies of artificial intelligence are having a significant influence on information systems (IS) design and analysis. At the same time IS sustainability is now one of the key 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 IS sustainability. The paper also contains theoretical foundations of information systems architecture and the brief overview of spatial sciences development in Russia.

Keywords: sustainability of information systems, soft computing, Fuzzy logic methods, scoring model

1. Introduction

In Russia today the use of advanced information technologies in economy and management is a key factor in improving organizational performance and increasing competitiveness. Distinctive features of the successful companies are sustainable business model, innovation, adaptability, and a deep understanding of consumer preferences. 80% of Russian executives believe that information communication technologies are playing a dominant role in the use of innovative business models and strategic goals realization. Information communication technologies (ICT) can reduce operating costs and increase profitability. Influenced by information technologies the activities of the company's basic departments (marketing, sales, and finance) are changing. This is due to the more efficient accumulation and analysis information. ICT can govern the ability of companies to generate the sustainable business models (Chesbroug, 2003, 2006; Osterwalder and Pigneur, 2010; Serova, 2013a). In industrial countries the questions of selection and application of modern information systems and technologies for strategic business objectives and market needs are in the spotlight. At the same time 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.

At present intelligent information systems and technologies are evolving actively. These technologies and systems are based largely not on tangible, but on information and communication resources that belong to the class of synergistic resources. The class of intelligent information technologies (IIT) and systems, including multi-agent systems (MAS), neural network (NN), and fussy logic (FL) continues to improve (Serova, 2013c). IIT are developed rapidly over the past ten years and they allow creating models of interaction between different kinds of spaces. Simultaneously IS sustainability is now one of the key drivers of business success. Paper contains the brief review and comparison of soft computing methods and techniques, and it focuses on the various intelligent modeling methods that are employed in evaluation of sustainability of information systems architecture in management and economy. The paper describes the main features of soft computing, discusses its implementation for design of sustainable information systems, and considers the role of fuzzy logic method and using scoring model of IS sustainability. It does so from research base that draws from theoretical underpinnings as well as international and domestic industry practices.

2. Theoretical background

2.1 Information system architecture

Variety of information systems applications for solving problems in management and economics has led to the requirement of using of information processes and technologies together with systems approach based on information systems architecture. When it comes to what actually is meant by the term "information system architecture", there is not usually lack of definitions. For example, there are a few tens of system architecture definitions on the site of Software Engineering Institute (SEI, 2014). Here are some of them:

- The architecture of a system is an abstraction of the system giving the semantics and specification for the patterns of information content and context.
- System architecture defines the physical, logical and information elements of the system which come together to realise a required set of functionality
- Architecture is the identification of different building blocks of the system according to their responsibilities, external properties of these blocks and their interrelationships.
- Architecture - the organizational structure of a system
- Architecture defines the data, processes, and components that make up the overall information system, and provides a plan from which products can be procured—and systems developed—that will work together to implement business solutions. Simply put, architecture provides the direction to make technology work for the business.
- Architecture is defined by the recommended practice as the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution.

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 (Sovetov et al, 2012):

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

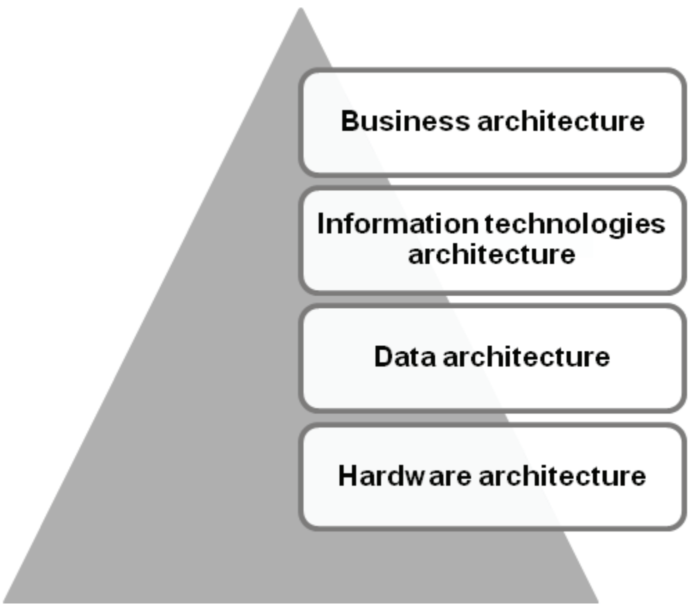

Figure 1: Information system architecture

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 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 information architecture of information systems is possible based on the applying of such intelligence information technologies as neural networks and fuzzy logic.

The group of modern enterprise management systems, in the first place, includes Enterprise Information Systems (EIS) - systems using various information technologies. EISs serve for data processing of different information flows on the different management levels.

It should be noted that there is no generally accepted classification, but as a rule, the strategic level systems include analytical retrieval systems technology-based Data Mining, expert information systems (EIS), Executive Support Systems (ESS), and Decision Support Systems (DSS). IS of the middle management level include Knowledge Management Systems (KMS) and Management Information Systems (MIS). Transaction Processing Systems and Office Automation Systems are used on the operation level of management (Pearlson et al, 2006; Rainer et al, 2006; Kazantsev et al, 2007; Turban et al, 2008; Serova, 2012b). Today in the publications on the topic of business efficiency and competitiveness of enterprises, many names and acronyms are mentioned, such as Product Lifecycle Management (PLM), Supplier Relation Management (SCM), Customer Relation Management (CRM) (Payne, 2006), and ERP. These names come after the concepts and management techniques used by successful companies. Interest in them is growing in Russia. Leaders of Russian companies are increasingly turning to the experience of the use of solutions that help integrate the people, information and business processes to effectively manage all areas of business. The term ERP — Enterprise Resource Planning, is one of the key issues in this series of current concepts. According to Serova (2012b), the recent trends in the development of enterprise information systems are associated with the intention to use information generated within the company, in the external environment to ensure cooperation with other enterprises, customers and partners. Today we should take into account the new concept of Enterprise Information System: the emphasis is placed on the EIS which is opened for the all partners operating in common business interests instead of on traditional internal business process management optimization. This concept includes five new tendencies (Serova, 2012b):

- *Change the role of ERP system.* Automation the internal business processes as well as external, counteragent relationships: customers, suppliers, banks, tax authorities;
- *The system technologies move towards an openness and transparency.* Internal processes are becoming more open. Information and data about activity of an enterprise can be available for business society member. Use of Web-technologies.
- *Structural changes of system architecture*. Instead of closed monolithic platform – open multilevel applications built on concepts of service-oriented architecture (SOA). Use E-SOA;
- *Expansion of system implementation.* Adaptation for enterprises of different kinds and sizes;
- *Deepen the system functionality.* All enterprise business processes should be automated;

2.2 Brief history and theory of the “economic space”

The definition and conceptual framework of the Spatial Sciences are still in the stage of discussion and debate. Several scientific schools of spatial economics were founded in Russia: in St. Petersburg and Moscow, Far Eastern school, Siberian school, and the Ural school. The Economic Research Institute of the Russian Academy of Sciences (RAS), with the support of the Scientific Council for Regional Development at the RAS Presidium, has been publishing the academic journal “Spatial Economics” since 2005. RAS’s research program “Fundamental Problems of Spatial Development of the Russian Federation: an Interdisciplinary Synthesis” was started in 2009.

In accordance with the basic hypothesis of the program, spatial science is defined as an interdisciplinary scientific direction, and objects of research are forms and processes of a modern society, which are space-dependent (Granberg, 2009). Three statements are offered as a conceptual basis. They related to the spatial, regional and international aspects.

In the other countries the attention of the public to scientific research in the area of spatial sciences and spatial development is also growing. “Journal of Spatial Science” has being published in Australia (information available from the website: MSIA mapping science institute, 2012).

Famous international publisher Springer has produced more than 40 volumes of the series “Advances in Spatial Science” (information available from the website: Springer, 2013). U.S. National Science Foundation (NSF) has approved a strategic plan for research in 2008-2012 entitled “Geography Spatial Sciences” (information available from the website NSF National Science Foundation, 2013).

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 (Krasnopol’skii, 2010).

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 (Bagiev et al, 2012).

3. Intelligence information technologies for architectural design of spatial information systems

The increasing demand for optimization of architecture of spatial information systems has caused leading modelers to consider intellectual information technologies and computer modeling in order to obtain deeper insights into complex and interdependent processes.

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 (Pidd, 2004). 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 (Serova, 2012a). 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.

The major approaches (or methods) in simulation for business are: System Dynamics (SD), Discrete Event (DE) and Agent Based (AB). While SD and DE are traditional approaches, AB is relatively new. Compared to SD or DE models, AB models do not allow the definition of global system behaviour (dynamics); instead, the modeler defines behaviour at individual level, and global behaviour emerges as a result of the actions of multiple actors, each following its own behaviour rules, living together in some environment and communicating with each other and with the environment (Borshchev, Filipov, 2004; Serova, 2013c).

Multi-Agent Systems as a system of distributed artificial intelligence, integrated into the information structure of the company, may be considered as an effective tool for spatiotemporal analysis of marketing information resources and creating of architecture of spatial marketing information system. With the using Agent Based Modeling we can obtain and analyse geospatial data, create models, linked to geographic coordinates and to develop of geoinformation architecture of complex marketing systems. Multi-Agent systems and agent-oriented programming represent a step forward from object-oriented programming (OOP) and integrate the latest advances in the areas of artificial intelligence, parallel computing, and telecommunications.
Any MAS consists of the following components:

- A set of organizational units with a subset of agents and objects;
- A set of tasks;
- A business ecosystems - a space where agents and objects exist;
- A set of relations between agents;
- A set of agent actions (operations on objects).

Intellectual agents have the most comprehensive set of qualities; their intellectual capacity allows them to build virtual worlds where they form action plans. Minimum set of basic characteristics for any agent includes qualities such as activity, autonomy, adaptability, and reactivity.

As systems of distributed artificial intelligence, Multi-agent Systems have the following advantages which can be successfully use for marketing spatial research (Serova, 2013):

- They speed up task fulfilment through parallelism and reduce the volume of data transmitted by passing high-level partial solutions to other agents;
- They are flexible since agents of various capacities are used to carry out a task dynamically cooperatively;
- They are reliable given that functions that one agent is unable to carry out will be passed to other agents.

Agent technologies usually involve the use of certain typologies of agents, their models and MAS architectures. These technologies are based on appropriate agent libraries and tools which serve for support development of different types multi-agent systems.

Applying multi-agent systems in order to design information architecture of marketing spatial systems can consist in the following (Serova, 2013c):

- To simulate and forecast clients' behaviour, both adopted and potential ones';
- To coordinate dealers and remote divisions based on multi-agent system;
- To automate and improve the customer support process within the CRM concept;
- To store knowledge and skills of marketing and sales specialists in the relevant agents' databases;
- To develop an integrated multi-agent Internet portal for agents to keep users' personal contents;
- To create a search agents to monitor outside information;
- To organize a distance-learning portal.

3.1 Fuzzy logic method for design of sustainable architecture of information systems

Design of sustainable and adaptive information architecture of spatial information systems is possible based on the applying of such intelligence information technologies as neural networks and fuzzy logic. Neural networks and fuzzy logic - are methods related to Soft Computing (SC). 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 (FS) was introduced by Lotfi A. Zadeh (Zadeh, 1994) 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 (Kecman, 2001; Krichevskii, 2005; McNelis, 2005).

Soft computing techniques are meant to operate in an environment that is subject to uncertainty and imprecision. According to Zadeh (Zadeh, 1994), the guiding principle of soft computing is: exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness, low solution cost and better rapport with reality .Fuzzy technologies as technologies of artificial intelligence are now having a significant influence on information systems design and analysis. At the same time IS sustainability is now one of the key drivers of business success. On the application level fuzzy logic can be considered as efficient tool for embedding structured human knowledge into useful algorithms. Mathematical models simplify and conceptualize events in nature and human activities by employing various types of equations which must be solved. However, the use of mathematical models gives rise to the question how accurate they reflect reality. In complicated cases the creating of such models might be impossible. Fuzzy models will become more and more popular as solution schemes, and it will make fuzzy systems theory a routine as opposed to its previous status as a “new, but curious technology”. Fuzzy logic models employ fuzzy sets to handle and describe imprecise and complex phenomena and use logic operations to find a solution. The goal of control process in management is making the decision. It might be also suggestion, instruction, conclusion, evaluation, forecasting. A block diagram of Fuzzy logic model is represented in Figure 2.

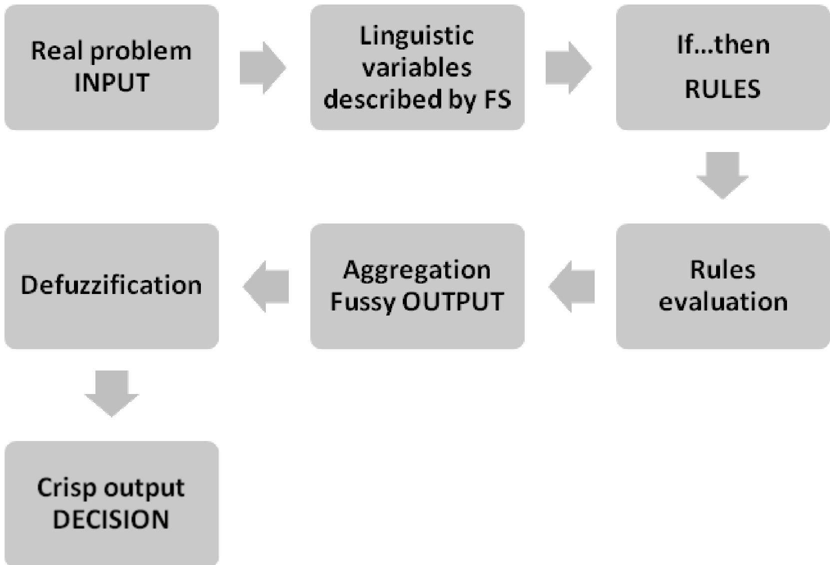

Figure 2: Block diagram of FL model creating

4. Creating model of assessment of IS sustainability

This section of the paper is devoted to the creation of FL model with the purpose of assessment of product diffusion system sustainability. Potential Adopters become Adopters at Adoption Rate that depends on advertising and word of mouth promotion. The figure 3 shows the fuzzy inference system (FIS) for three input variables and one output parameter. This FIS is destined for the assessment of the IS sustainability. The input parameters are advertisement (ad), contact rate (cr), number of potential adopters (npa). Three selected attributes are included as input data to a fuzzy inference system. The output parameter determines the IS sustainability as the adoption fraction (af).The control objective is to find the output value for a particular set of input variables. Each of input parameters is the linguistic variable with three terms: *low, middle, big*. Membership functions characterize the fuzziness in a fuzzy set in a graphical form for eventual use in the mathematical formalisms of fuzzy set theory. The Figure 4 gives the information about the membership functions for the input and output variables. All calculations were performed in MATLAB v. 7.01.

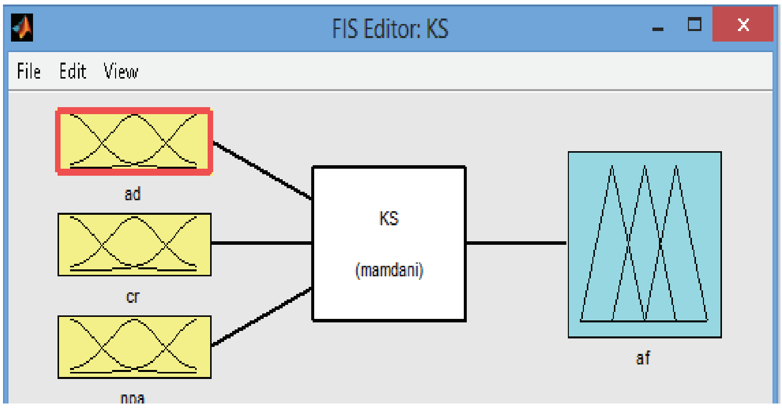

Figure 3: Fuzzy inference system (FIS)

The next step is definition of the FIS rules. The number of the rules is the product of the number of terms in each input variable: 3*3*2 = 18. After forming bases of rules FIS gives the values of IS sustainability as conditional units. We finally get a crisp value of the output which represents the values of IS sustainability. Figure 4 displays the value of sustainability equal 0.12 for given set of input variables: ad = 6.8; cr = 26.1; nap = 11.The fuzzy approach for assessment of IS sustainability was supplemented by the regression equation in conclusion. In the first step all input variables were modeled by Monte-Carlo method. In the second step the modeled inputs were introduced into the FIS and the values of IS sustainability were formed as outputs of the FIS.

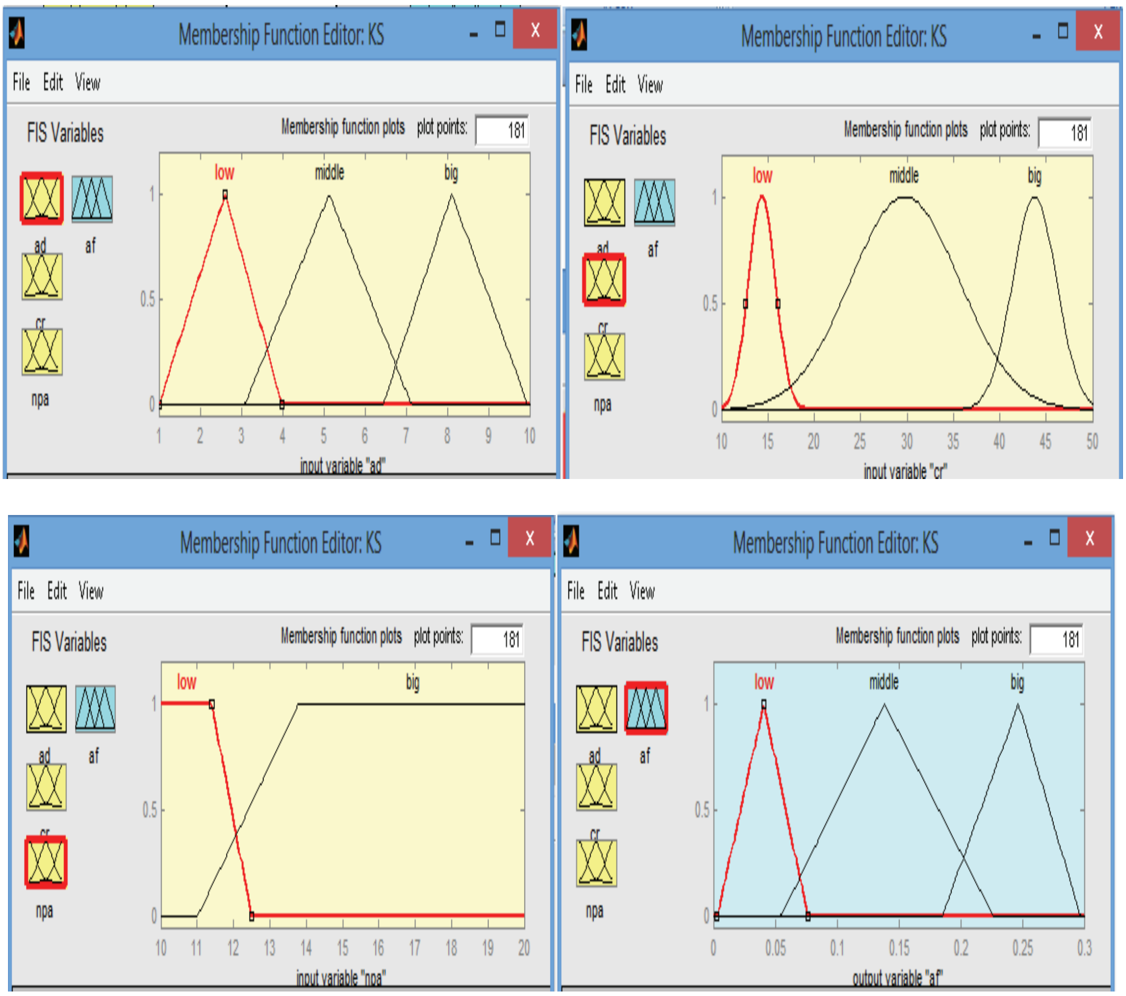

Figure 4: Membership functions for the input and output variables

Table 1 contains the modeled inputs and the values of IS sustainability calculated by FIS (the fourth column).

Table1: The modeled inputs and calculated outputs

1	X1	X2	X3	Y (Fuzzy Logic)	Y(Regression)
2	5,0	34	0,18	0,04	0,070
3	3,6	20	0,11	0,092	0,109
4	5,9	35	0,14	0,041	0,085
5	7,4	36	0,12	0,153	0,144
6	7,3	38	0,20	0,149	0,149
7	8,1	42	0,15	0,163	0,128
8	2,2	22	0,26	0,102	0,069
9	5,1	32	0,13	0,04	0,077
10	7,1	35	0,08	0,14	0,127
11	3,9	29	0,07	0,063	0,024

In the third step the regression equation was derived with the use the first four columns of Table 1. The regression equation is of the form

$$Y = 0.085+0.046*X1 - 0.01*X2 + 0.33*X3,$$

where $X1$, $X2$, $X3$ - are advertisement, contact rate, number potential adopter; Y - numerical value of IS sustainability.

The last column of Table 1 contains the value of IS sustainability which is calculated by the regression equation. The comparison of the values of IS sustainability calculated by FIS (the fourth column of the table 1) and the regression equation (the fifth column) shows their similarities. Thus the derived regression equation can be used to assess the numerical value of IS sustainability.

5. Conclusion

At present the use of the latest achievements in the field of Information Communication Technologies (ICT) in economy and management, including the contemporary methods and tools of computer modeling is one of the key factors in improving organizational performance and increasing its competitiveness. Formation of architecture of spatial systems is determined by the problem increased use of spatial information in sustainable development of the territories and is one of the perspective areas of research in the field of spatial information systems. Theoretical and empirical researches prove that spatiotemporal analysis of data can be performed through applying of contemporary intelligent information technologies with using multi-agent systems as systems of distributed artificial intelligence. Architecture of spatial information system can be considered as a concept, which determines the model, the structure, functions and components' relationship. Building a sustainable architecture of management information systems, including marketing information system, is possible with the use of soft computing methods, such as fuzzy logic.

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