Preface

Motivation

Manufacturer of digital products become a driver of the world's economy. This claim is confirmed by the data of the European and the American stock markets. Digital products are distributed in the Internet, serviced by the intellectual property protection solutions and internet payment systems. Online trade platforms support distribution of a variety of products in digital form, which are the result of intellectual work at both conceptual and manufacturing stages. Moreover, the approach to production itself has to be modified to meet demands of knowledge-based production.

The modern information and production system is a complex system since many components have their own goals that determine their behaviour. Moreover, these components are mutually related but can have conflicting goals. The complexity arises from the fact that it strives to satisfy and make use of many different stakeholders and resources: clients, workers, organizations, IT systems, telecommunication infrastructure and information and knowledge resources.

When considering different knowledge-based systems, we see, in addition to various artificial intelligence methods, a strong emphasis on cooperation between knowledge workers. Knowledge workers are the most important source of knowledge for the system and form the core of the intellectual capital of a knowledge-based organization. The quality of their cooperation depends on their motivation, competence and cognitive abilities. In our opinion, it is motivation that makes workers to apply their cognitive abilities to develop new the competencies. In this approach incentive mechanisms become the most important component of management in knowledge-based organizations. They encourage the continuous process of knowledge transfer. Generally speaking, incentive means motivating a subject to perform specific actions. In organizational systems a principal stimulates an agent by exerting an impact on his or her preferences (i.e. the goal function). In the book we shift from individual incentive systems (single-agent organizational systems) and focus on collective incentive systems, which provide incentives for a

collective of agents. An agent in a multi-agent organization system can be independent (non-interacting) or collaborative (interacting with other agents). We also have to deal with some level of uncertainty of agents' actions and characteristics. Our goal is to apply incentive mechanisms to the knowledge-based production and information system.

This book consists of 12 chapters, each revised by the editors. The chapters are grouped into three perspectives. The first perspective is focused on theoretical aspects of knowledge-based production and systems. The second perspective goes deep into applications of presented theoretical concepts and approaches in production. The third perspective focuses on applications in information systems. Below we survey the content of all chapters in more detail.

Theoretical Perspective

The first chapter is focused on *Teams: Building, Adaptation and Learning* (Novikov D.A.). A team is a collective ability to achieve a goal in an autonomous and self-coordinated way under the minimum control actions. For many years various aspects of team behaviour (formation, decision-making, coordination, adaptation, specialization, etc.) attract acute attention of psychology, political science, control theory and production studies. This chapter considers game-theoretic models of team building, team adaptation and team learning in multi-agent organizational systems and challenges the problem of inconsistent information of team members while performing the joint activity. It is shown that models of team building and operation described in terms of reflexive games reproduce the autonomy and coordination of team activity. Team adaptation is considered as the process of beliefs' updating under the absence of common knowledge among the agents. In the framework of the joint learning model, the optimal learning problem is stated and solved as the allocation of the work volume performed by agents in certain time intervals.

The second chapter entitled *Incentive Mechanisms for Multi-agent Organizational Systems* (Novikov D.A.), presents a brief (yet comprehensive) introduction to the state of the art in the theory of incentive mechanisms for multi-agent systems under complete information. First, the approach is explained by the theory of financial incentives in organizations, including the game-theoretic grounds and the principal-agent model. Optimal individual incentive schemes are considered as long as collective ones, including the case of information aggregation. Three main principles of optimal incentive scheme design for interacting agents are derived, namely, the principle of compensation, the principle of decomposition and the principle of aggregation. Models of agents' self-coordination in the absence of the central authority are explored in terms of side-payoff games. These models are of great interest in the context of multi-agent approach in distributed control. Finally, the problem of agents' preferences

identification in firms is studied in terms of revelation of labour supply curves from electronic surveys.

The chapter *Optimal Organizational Structures for Change Management in Production* (Goubko M.) considers the problem of a rational organizational structure for change management support being an important aspect of the strategic management process in a firm. Recent theoretical findings are combined with experience in strategic consulting to suggest mathematical models of an organizational structure for change management based on the formal representation of a strategy of the firm and of available personnel resources. The model of managers' interactions employs an idea of efforts' duplication.

The problem of an optimal organizational structure is reduced to a complex mixed optimization problem. Then a problem of an optimal organizational form (functional vs. divisional vs. matrix) is considered for a special case of identical and "symmetric" projects of strategic development. It is shown that the span of control should be constant across the levels of an optimal functional, divisional and matrix hierarchy; costs of optimal organizational forms are compared. The matrix organizational structure appears to be optimal when the number of projects and managerial functions are large enough. Ii is also shown that matrix and divisional organizations are robust with respect to the project count increase.

The next chapter is entitled *Knowledge-Based Models of Nonlinear Systems Based on Inductive Learning* (Bakhtadze N.N., Lototsky V.A.). The class of knowledge used today in production process control systems is more extensive than the expert knowledge class. In knowledge-based manufacturing systems (KBMS), artificial intelligence operating with process knowledge along with expert knowledge is widely used. The term "process knowledge" means formalized process operation regularities obtained by means of data analysis. Knowledge management in process control systems enables application of control techniques with intelligent predictive models (automatic control or managerial decision-making support) as well as of network, multi-agent, and multimodal techniques. In this chapter, the predictive model design is carried out using intelligent algorithms of nonlinear dynamic system identification. Those are based on inductive learning: associative search of analogues by intelligent analysis of both archives of system technology parameters (data mining) and the process knowledge base. The chapter examines multimodal plants in process and power industries. For such objects a stability criterion is suggested, which is expressed in terms of wavelet analysis, and a new identification algorithm is proposed based on associative search techniques.

The chapter *Multiple Criteria Decision Support System for Tender Consortium Building Within the Cluster Organization* (Małachowski B.) covers the multiple-criteria decision support method of contractors' consortium building basing on the analogy to project management methods used to support project team building within project-oriented organizations. The method supports a consortium leader in the process of consortium building. The method is based on fuzzy sets and the graph theory. In real life the decision about the consortium composition relies on many qualitative and quantitative criteria with the qualitative criterion of competence being of significant importance. The main advantage of the discussed

approach is the quantitative formal model of competences, which allow precise selection and allocation of consortium members. Moreover, the complexity of the necessary multiple-criteria decision analysis can be reduced sufficiently by introducing a set of company pre-assignment conditions and a set of variant qualification constraints.

The last chapter in this part is entitled *Guideline for MCDA Method Selection in Production Management Area* (Wątróbski J., Jankowski J.) and considers the problems of rationalizing the choice of the multi-criteria decision-aid (MCDA) methods, which are well-suited to solve a given decision problem. Two sources of factors, which influence the choice of the method, are identified: a subject of the decision and the characteristics of the problem description. The technique proposed allows choosing one method from the considered group of methods. Practical verification of suggested decision rules was carried out for referential sets of sample literature applications (over 20 cases) of MCDA in the area of production management.

Applications in Production

In the chapter *Declarative Modelling Driven Approach to Portfolio Prototyping of Production Orders* (Banaszak Z., Bocewicz G.) the problem of production management under the large number of uncertain factors is considered. Using the apparatus of fuzzy logic the authors set the direct problem of job scheduling and the inverse problem of production resources assignment. The suggested solution approach is based on the original concept of the, so-called, "declarative" modelling. In models of this sort only the most important characteristics of the manufacturing process are taken into account. The chapter is equipped with numerous examples to illustrate and confirm the proposed approach.

In the chapter *A Knowledge-Based System for New Product Portfolio Selection* (Relich M.) authors establish a relationship between the success of a new product (NDP—New Development Product) and the key factors of success calculated from the enterprise information system. Effective management of NPD projects is a challenging goal due to numerous factors of complexity, such as intensive research and development investment, long and uncertain development times, low probability of technical success, uncertain market impact and competition. The proposed approach takes into account the data of previous projects that can be retrieved from different modules of an enterprise information system (e.g. marketing and sales, production, project management and customer claim control). Fuzzy neural networks are used to reveal relationships between product success and metrics of the NPD process. The identified relationships are expressed in the form of "if-then" rules. The proposed knowledge-based system uses these rules to estimate net profit for prospective products considered for development and suggests a set of the most promising products according to manager's preferences. The knowledge-based system can also be used for simulation and identification of such changes in the

project environment that can increase the chance to develop a successful product. The set of potential products for development is determined with the use of constraint programming taking into account the company's constraints.

The chapter *Knowledge-Based Models for Smart Grid* (Yadykin I.B., Maximov E.M.) represents application of the multi-agent technology to smart grid, unified the grids, consumers and generating facilities. Authors suggest the design technique for intelligent, multimodal, large scale energy networks. Design of the multi-agent control system (MACS) is based on the development of MACS standards and classifications. The authors solve the control stability problem using the method of Gramians to determine the degree of stability. To solve the problem of control stability in time and frequency domain authors apply the method of differential and algebraic Lyapunov equations. Much attention is paid to the development of multi-agent intelligent optimization approach, which allows developing the technology of controlling the degree of MACS stability. This chapter also offers a concept of an intelligent multi-agent system that maintains stability in Russian Smart Grid, which incorporates an active analytical network and new algorithms to determine the degree of system stability using Gramians.

Applications in Information Systems

In the first chapter of this part, *Transformations of Standardized MLP Models and Linguistic Data in the Computerized Decision Support System*, (Becker J., Jankowski J., Wątróbski J.), the authors focus on two complementary issues of DSS. The first one is transformation of the data form and second one is transformation of structures of MLP decision models. The aim of proposition concept in DSS is to deal with multi-stage and multi-criterial nature of the decision-making process, number of decision-makers and experts, scale of the decision problem, flexibility of decision variants and linguistics of data. The information structure of partial mathematical models, reflecting the objects of analysis, are transformed to the form of records of the database and on their connection into a more complex structure, so-called multi-model. Data transformations are based on the use of fuzzy set logic and scoring and linguistic scales are of the ordinal nature.

The second chapter is entitled *New Frontiers and Possibility in the Construction of Learning Systems with Using of the Educational Program Complex "Labyrinth of Knowledge"* (Zapevalina A.A., Troyanovskij V.M., Serdyuk O.A.). The learning process analysis requires the implementation of a set of operating modes: view mode and the transfer of knowledge, controlling regime, account of individual abilities of students, adaptation, development and updating of the knowledge base. Algorithms and software for "labyrinth of knowledge" allow implementing these processes technically by interactive training with use modern gaming methods. Connection of control methods, technical capabilities of computational tools and modern information technology allows to create an effective learning environment with functions of adaptive simulator.

The last chapter *Scenario Analysis in the Management of Regional Security and Social Stability* (Kulba V., Zaikin O., Shelkov A., Chernov I.) represents the methodological and applied issues of development the management processes of regional security. It describes the methodology of diagnosis, structural analysis and evaluation of the major threats to regional security. The problems of countering the destructive information effects based on misinformation and manipulation technologies are examined. The results of the analysis of the main features of the management processes of regional security are presented. There are the mechanisms of the use of scenario analysis in the management of socio—economic development of the region and ensuring its protection against external and internal threats to social stability. A formalized methodology to assess the effectiveness and efficiency of management of regional security is considered. The results of the scenario study investigation of multi-graph management models of regional security are given.

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