

## THE SYNTHESIS OF STABILIZATION SYSTEMS UNDER ONE-SIDED RESTRICTIONS ON CONTROL ACTIONS

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**Abstract.** In practical applications of automatic control theory, situations are often encountered where control actions are limited to a certain range of values, in particular, they can only take non-negative values. In this case, such popular synthesis methods as modal and optimal control are not applicable. In this paper, the methods are proposed for stabilizing output (controlled) variables in linear stationary SISO systems under non-negative (unipolar) control constraints. The main idea is to implement control actions in the form of linear functions with saturation, constant values of which coincide with the restrictions on the controls. As an illustration of the developed algorithms, a pulsed DC/DC voltage converter is considered, in which the control has a switching nature with the «on – off» states. The simulation results in Matlab Simulink are presented.

**Keywords:** stabilization problem, one-sided control restrictions, invariance, DC/DC voltage converter.

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## DESIGN OF INTEGRATED MECHANISMS FOR ORGANIZATIONAL BEHAVIOR CONTROL

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**Abstract.** A mathematical model and a notation are developed of integrated mechanisms for problems of organizational behavior management. Singular basic mechanisms (resource allotment mechanisms, incentive schemes, monitoring and audit procedures) are combined into an acyclic graph of a multi-stage game, which reflects the structure of a business process in an organization. Instead of stochastic games on graphs, in this notation not just standard normal-form games but sophisticated principal-agent mechanisms with incomplete and asymmetric information can be located in graph nodes. Integrated mechanisms are analyzed using a backward induction procedure through an acyclic graph of a multi-stage game, which models the considered organizational interaction. This approach allows to reuse the best practices of organizational mechanisms developed by mechanism design and the theory of organizational behavior control for typical situations of principal-agent interaction that arise in managerial practice. These singular mechanisms are used as building blocks when a complex integrated mechanism is constructed, while their optimality and strategyproofness are preserved. Efficiency of alternative basic mechanisms (e. g. different auction rules) can be tested against a specific position (a node of a multi-stage graph game) in an integrated mechanism. The method is illustrated by simple examples of the design of integrated mechanisms for resource allotment, incentives' provision, and monitoring, and directions of prospective studies are outlined.

**Keywords:** basic mechanism for organizational behavior management, multistage stochastic game on graph, backward induction, strongly related mechanisms.

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## MULTIDIMENSIONAL MODEL OF OPINION DYNAMICS IN SOCIAL NETWORKS: POLARIZATION INDICES

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**Abstract.** We consider a multidimensional model of opinion dynamics in social networks. Within the framework of the model, the dynamics of two interconnected information processes in a social network is studied. The first process is the excitation of agents and their externally observed actions (e. g., in the form of messages published in the network). The second process, which has an obvious connection with the first one, is the formation of agents' opinions (which are a characteristic of their internal state). We demonstrate that the proposed model of opinion dynamics is flexible, allowing to take into account the significant effects of opinion formation in social networks, including consensus or agreement of opinions, preservation of differences in the agents' opinions, and even polarization of opinions. We propose approaches to measuring the polarization of opinions and present the simulation results. We show that the proposed polarization index for a network allows us to distinguish and evaluate situations with meaningfully different multidimensional distributions of opinions in a social network, as well as to find directions for the greatest polarization.

**Keywords:** social network, opinion dynamics, activity spreading, opinions polarization, polarization measures.

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## GAME-THEORETIC THRESHOLD MODEL OF THE STOCK MARKET

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**Abstract.** The game-theoretic model of the binary threshold collective behavior of agents who participate in the sale and purchase of a single exchange asset is considered. The agents were divided into two groups – buyers and sellers. It was assumed that for each of the agents, a threshold of acceptable price exists; for the buyer – it is the upper price at which he still agrees to make the transaction, and for the seller – it is the lower «comfortable» price. It was taken into account that the agent decides whether to participate in the transaction by comparing his threshold price with the market price. It was assumed that the market price is affected by the volumes of supply and demand in accordance with the classic supply and demand curves. Empirical distribution functions of price thresholds are constructed, which are used to characterize Nash equilibrium, and also allow to study the limit transition to an infinite number of agents in the future. A theorem on the characterization of Nash equilibrium is proved, the first part of which shows the volumes of potential supply and demand. The second part of this characterization presents the state of agents based on the volumes of

supply and demand. We studied examples of the existence and uniqueness conditions for Nash equilibrium. Focal points are found among all Nash equilibria.

**Keywords:** game-theoretic model, binary threshold collective behavior, exchange commodity market, Nash equilibrium.

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## THE ESTIMATION MODEL OF THE MORTGAGE SECURITIZATION EFFECT ON BANKING BUSINESS

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**Abstract.** The paper is devoted to the development of the mortgage securitization market in Russia. The aim of the study is to assess the average effect of mortgage securitization transactions on the performance of Russian banks that executed such transactions in the period from 2012 to 2018. The Propensity Score Matching methodology, which is applied for assessing the effect of the event on a particular object or a process, was used in this research. The data was collected from the Cbonds database that contains information on the dates and volumes of securitization transactions in the Russian Federation, while bank performance indicators were gathered from the Bank of Russia database. The results demonstrated that the main positive effect of securitization for Russian banks in the analyzed period was the growth of liquid assets, whereas the negative ones were a lower yield of the loan portfolio and its quality deterioration. Unlike foreign practices, securitization did not bring Russian banks the benefits associated with a reduction in funding costs and increased profitability. The outcome of the research contributes to the theory of banks financial stability and could be useful, both for banks when deciding on securitization and for supervisors for regulatory purposes. The practical value for the risk management of banks is represented by the conclusion concerning the use of securitization as a source of liquidity in the context of a structural liquidity deficit. The potential power of securitization with regard to the banking efficiency enhancement could be released by regulatory measures aimed at improving its mechanism.

**Keywords:** banking sector, mortgage lending, mortgage securitization, liquidity, credit risk, profitability, financial soundness, systemic risk.

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## SECURITY THREAT ASSESSMENT METHODS FOR UNMANNED VEHICLES IN A SMART CITY

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**Abstract.** This paper presents a comprehensive cybersecurity model for autonomous vehicles (AV) system in framework of the smart city. We consider a problem of information flow description for a real AV system in the frame of discretionary security models. The definition of safe data transfer for some types of information exchange between the system assets is presented. Some techniques for asset classification in frame of Biba and Bell-LaPadula models taking into account information links between the assets are

introduced. We discuss the complexity and ambiguousness of the «integrity» definitions in relation to cybersecurity provision and emphasize the significance of its extension to the equipment and data processing methods. This approach is considered to shift the focus to the system analysis and system vulnerability removal and to develop the protection upon the system internal properties. Dynamical methods of cybersecurity architecture synthesis for transport systems with AVs are considered. The methods are shown to lessen computational complexity of system modelling. Instead of analyzing the complete security graph, one may analyze an induced subgraph for a given AV. The vertices (assets) of full security graph are excluded from the consideration if they are at a great «distance» from the analyzed AV. Formulae for the distance calculation are provided for some cases. Some examples of cybersecurity architecture analysis and synthesis for autonomous vehicles are presented.

**Keywords:** cybersecurity, autonomous vehicles, smart city, security architecture, classification, clustering, security graph, take-grant model.

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## FAULT-TOLERANT NON-BLOCKING THREE-DIMENSIONAL SPARSE HYPERCUBE

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**Abstract.** A system network is proposed in the form of a non-blocking fault-tolerant three-dimensional generalized  $p$ -ary hypercube with a single processor in each node of the hypercube. In any non-blocking network, data between processors is transmitted over direct channels with the lowest latencies and without intermediate buffering. Networks with the topology of a generalized hypercube have the smallest lengths of direct channels and the smallest transmission delays. The structure of this hypercube based on networks with the topology of a quasi-complete graph is developed, which allows exchanging the number of processors for the number of different direct channels between any processors and setting the channel and node fault tolerance of the network. The parameters of quasi-complete graphs that exist for any  $p$ -identity of a hypercube are given. As a result, a network structure is proposed in the form of a sparse  $p$ -ary hypercube with a number of nodes slightly smaller than in a regular  $p$ -ary hypercube. The sparse hypercube is designed as a fault-tolerant system network for a single-chip processor accelerator with several hundred cores. A procedure and an algorithm for the laying of conflict-free direct channels through dynamic local packet self-routing has been developed, in which the nodes do not interact with each other and use only extended routing information from the packets.

**Keywords:** system network, quasi-complete graph, generalized hypercube, channel fault tolerance, switching properties, non-blocking network, conflict-free direct channels, local dynamic self-routing.

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## TARGET SURVIVAL PROBABILITY ESTIMATION FOR THE ATTACKERS – TARGET – DEFENDERS PROBLEM

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**Abstract.** The attackers-target-defenders problem is formulated and formalized as a positional antagonistic game with incomplete information. A method of target survival probability estimation with known estimates of the dynamic capabilities of attackers is proposed. Recurrence expressions for its calculation are obtained. Corresponding numerical target survival probability estimations with optimal behavior of the players are made. Defenders in the game are assigned three different roles: the role of a false goal, the role of a goal accompanying, and the role of an intercepting attacker. Survival probability considered as function of the attackers-target-defenders problem parameters is analyzed. The obtained probability estimations could be used as heuristic estimations of quality for corresponding dynamic system. Obtained optimal strategies could be considered as heuristics for the corresponding attackers-target-defender differential game. Optimal strategies contain orders for players indicating their current role. Using the Python language, a software module was developed that allows to calculate the survival probability of a target based on known task parameters.

**Keywords:** attackers-target-defenders, false targets, positional game, antagonistic game, incomplete information, dynamic programming.

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## XII INTERNATIONAL CONFERENCE «MANAGEMENT OF LARGE-SCALE SYSTEM DEVELOPMENT» MLSD'2019

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**Abstract.** Scientific results of participants of the conference that took place in October of 2019 are presented. Among the thematic directions (sections) of the conference were management problems of large-scale system development in different areas, such as banking and finances, infrastructure and transport, healthcare and society, etc.; methods and tools for managing investment projects and programs; management of development of a digital economy; simulation and optimization in the problems of development management of large-scale systems; nonlinear processes and computing methods in the problems of management of large-scale systems; managing the development of regional, urban and municipal systems; management of objects of nuclear power and other objects of increased danger; information support and software management systems for large-scale production. Almost eight hundred authors presented 411 theses and 172 papers.

**Keywords:** conference, large-scale systems, digital economy.