

**ABSTRACTS**

**of the scientific publications of Assoc. Prof. Dr. Vladimir Vasilev Monov  
presented for participation in the competition for  
the academic position "professor"  
in professional field 4.6. "Informatics and Computer Sciences"  
specialty "Informatics"  
for the needs of "Modeling and Optimization" department of  
the Institute of Information and Communication Technologies-BAS,  
announced in "Darjaven Vestnik" no. 41 of 21.05.2019**

According to the attached list of all publications, the research results of Assoc. Prof. Dr. Vladimir Vassilev Monov are presently given in 103 publications, including one monographic work. One patent application for invention has been filed with the Bulgarian Patent Office. The distribution of the publications is as follows.

- 8 papers [1, 2, 3, 5, 6, 8, 9, 10] are in the dissertation thesis entitled "Decentralized control of large-scale linear systems" for the acquisition of the educational and scientific degree "doctor".

- 16 publications [4,7,11-13,15-25] are presented in a competition for "Associate Professor" (Senior Research Fellow II degree) in subject 01.01.12. "Informatics".

- 25 publications [30, 33-38, 39, 42, 44, 50, 57, 58, 60, 67, 69-72, 74, 78, 79, 85, 96, 97] are presented for review in this competition for the appointment of the academic position "Professor".

- 19 publications [40, 41, 45, 46, 48, 49, 51, 52, 53, 54, 61, 66, 68, 81, 86, 92, 93, 95, 103], the monograph [73] and the patent application are listed in the set of indicators  $\Gamma$  of the enclosed statement for fulfillment of the requirements for occupying the academic position "professor".

**List of editions of the papers presented for review**

- Cybernetics and Information Technologies, Prof. Marin Drinov Academic Publishing House, ISSN:1311-9702, SJR: 0.204. (publications [30,33,35,44]).
- Journal of Inequalities in Pure and Applied Mathematics, Victoria University, ISSN:1443-5756, SJR: 0.346. (publication [34]).
- Linear Algebra and its Applications, Elsevier, ISSN:0024-3796, WoS Quartile: Q1 and Q2, IF: 0.972, SJR: 0.994. (publications [36,39]).
- Comptes rendus de l'Academie bulgare des Sciences, Prof. Marin Drinov Academic Publishing House, ISSN:1310-1331, WoS Quartile: Q4, IF:0.27, SJR:0.210. (publications [37], [38]).
- Proceedings of Third International IEEE Conference on Information Science and Technology, 2013, Yangzhou, China. ISBN:978-1-4673-5137-9 (publication [50]).
- Lecture Notes in Computer Science, Springer, LNCS 7116 ISBN 978-3-642-29842-4, LNCS 8353 ISBN 978-3-662-43879-4, WoS Quartile: Q4, IF:0.402, SJR:0.339. (publication [42]).
- Springer Book Series "Advances in Intelligent Systems and Computing", Vol. 323, 2014, ISBN 978-3-319-11309-8, SJR:0.174, (publication [69]).
- Proc. of the Third International Conference on Telecommunications and Remote Sensing ICTRS'14, Luxembourg, Grand Duchy of Luxembourg, ISBN 978-989-758-033-8. (publication [67]).
- Proceedings of the International Conference on Mechanical and Industrial Engineering, ICMIE 2013, Venice, Italy, ISSN 2010-376X. (publications [57,58]).
- Proceedings of the International Conference on "Numerical Methods for Scientific Computations and Advanced Applications" (NMSCAA), 2014, Bansko, Bulgaria, ISBN : 978-954-91700-7-8. (publication [60]).
- Economic Alternatives, UNWE Publishing Complex, ISSN 1312 – 7462. (publications [70,71,72]).
- Proc. of the International Symposium on Business Modeling and Software Design – BMSD'15, Milan Italy, ISBN 978-989-758-111-3. (publication [74]).
- Int. Journal Information Models and Analyses, ITHEA, ISSN 1314-6416. (publication [78]).
- Information Technologies and Control, De Gruyter Open, ISSN 1312-2622. (publications [79,85])

- Springer book series “Communications in Computer and Information Science”, CCIS, Vol. 919, 2018, ISBN 978-3-319-99446-8. SJR:0.170. (publication [96]).
- Proceedings of the International Conference “Big Data, Knowledge and Control Systems Engineering BdKCSE’2018”, 2018, Sofia, Bulgaria, ISSN 2367-6450. (publication [97]).

### **Thematic directions in the papers presented for review**

#### ***Theory of matrices and application of matrix analysis in the study of dynamic systems and processes***

In the field of mathematics, matrix theory and linear algebra provide a subject for fruitful research whose results are applicable not only in its other areas, but also in information science, computer technology and a number of engineering and applied disciplines. The papers presented for review in this direction contain scientific results related to the establishment of criteria characterizing certain classes of matrices and matrix sets, proofs of matrix and scalar equations and inequalities, formal mathematical description and study of special matrix products. From an applying point of view, the obtained results refer to solving problems in the analysis of stability and robust behavior of linear continuous and discrete time systems with uncertain parameters, in the study of solutions of differential equation systems, in the modeling and examination of systems and processes with non-negative parameters.

#### ***Modeling, analysis and optimization in information and communication systems***

In today's information society, information and communications have an important role in scientific and applied research, with a wide range of research topics and numerous applications. The papers presented for review in this direction contain the developed models and algorithms for management and optimization of the information traffic in packet switches used in the communication systems, as well as results from computer modeling and large-scale computational simulations, establishing their properties and characteristics. Methods and tools for optimization and integration of data in wireless sensor networks and systems

have been developed. Program implementation of algorithms and a software system for optimization of production schedules are presented. A methodology for optimization of the process of implementation and exploitation of information systems for enterprise resource planning has been developed.

### **Abstracts of the papers presented for review**

**[30] Monov, V.V. An application of Caratheodory's theorem to the spectral set problem for convex matrix sets, Cybernetics and Information Technologies, vol. 1, № 2, pp.63-69, 2001.**

In the present work, the problem of characterizing the spectral set of a given convex set of square matrices is studied. For this purpose, a classical result from the mathematical analysis, known as the Karatheodory's theorem is used. The main result is formulated in Theorem 2.1 in which it is shown that the spectral set of each compact and convex set of real matrices with dimension  $n \times n$  can be obtained as a union of the spectra of matrix polyhedra with dimension no greater than  $2n$ . We have derived expressions that characterize separately both the real and the imaginary part of the spectrum. The main advantage of the obtained result is that it allows the spectral properties of convex matrix sets to be studied by examining the properties of their subsets with a simpler structure and a lower dimension.

**[33] Monov, V., M. Tsatsomeros. A criterion for reducibility of matrices, Cybernetics and Information Technologies, vol. 4, No 2, pp. 61-68, 2004.**

The concepts of invariant and reducing subspaces are well known in linear algebra and matrix theory. Invariant and reducing subspaces play a key role in the study of spectral properties and canonical forms of matrices and also have a number of important applications. In this work the problem of existence and characterization of non-trivial reducing subspaces for a given matrix is studied employing some basic tools of multilinear algebra. A criterion for reducibility of a single matrix is obtained which is also extended to the case of simultaneous reduction of two or more matrices. We have used the theoretical apparatus of multilinear algebra, and in particular, exterior algebra, Grassman spaces and their vector representatives. The construction of reducing subspaces for a pair of matrices is illustrated by a numerical example. Our study is motivated by the

numerous applications of the reducibility problem of matrices and linear operators in various fields, particularly in the field of linear control theory.

**[34] Monov, V. Newton's inequalities for families of complex numbers, Journal of Inequalities in Pure and Applied Mathematics, vol. 6, Issue 3, Article 78, 2005. SJR: 0.346.**

The well-known inequalities of Newton represent quadratic relations among the elementary symmetric functions of  $n$  real variables. One of the various consequences of these inequalities is the arithmetic mean-geometric mean (AM-GM) inequality for real nonnegative numbers. Different proofs and detailed research on these results are known. Modern literature also offers new families of Newton inequalities, as well as extended treatment of various issues related to these inequalities. The results, however are mostly limited to the case of real numbers. This paper presents an extension of Newton's inequalities involving elementary symmetric functions of complex variables. In particular, we consider  $n$ -tuples of complex numbers which are symmetric with respect to the real axis and obtain a complex variant of Newton's inequalities and the AM-GM inequality. The relationship of this result with certain classes of square matrices, whose eigenvalues satisfy the complex form of Newton's inequalities has been established.

**[35] Monov, V. Some properties of the characteristic polynomial of a nonnegative matrix, Cybernetics and Information Technologies, vol. 6, No 2, pp. 3-11, 2006.**

Square non-negative matrices are an important class in matrix theory with multiple applications, including information technologies and algorithms for information retrieval in large data bases. The spectral theory of non-negative matrices is also known as the theory of Perron-Frobenius because of the founding works of O. Perron in 1907 and G. Frobenius in 1908-1912. Subsequently, this theory is undergoing rapid development, and continues to be a subject of active research to the present. The presented article explores properties of the characteristic polynomial of non-negative matrices. It has been found that the fundamental spectral properties of this class of matrices are preserved and are also satisfied by the roots of all derivatives of the characteristic polynomial. The obtained results extend and enrich the main results in the theory of Perron and Frobenius. The proposed proof of Theorem 2 in our work generalizes the inductive approach used by G. Frobenius in his proof of O. Perron's theorem. The

analysis of the results obtained in the final part of the paper has given rise to the formulation of an open problem in the theory of non-negative matrices.

**[36] Monov, V. A family of symmetric polynomials of the eigenvalues of a matrix, *Linear Algebra and its Applications*, vol. 429, Issues 8-9, pp. 2199-2208, 2008. IF:0.972, Quartile: Q1 and Q2/SJR: 0.994.**

Symmetric polynomials and symmetric functions play an important role in various fields such as symmetric group representation theory, algebraic and analytic combinatorics, mathematical physics, and the study of certain matrix properties. In the presented article we have defined a family of symmetric polynomials of the eigenvalues of square matrices with complex elements. As special cases, the family includes the infinite power sums and the complete homogeneous symmetric polynomials of the matrix's eigenvalues. The main result in the article is the proven explicit formula, expressing each polynomial of the family as a sum of products of the matrix elements. An analytical approach, including scalar and matrix infinite power series is used in the proof. In the special case of non-negative matrices, a set of inequalities connecting expressions for the eigenvalues and diagonal elements of the matrix are obtained. A relationship of the obtained result with a classical result in the combinatorics (MacMahon's Master Theorem) has been established, and various applications are mentioned.

In the concluding part of this work, a conjecture on a set of inequalities associated with non-negative matrices is formulated, which would lead to solving a difficult problem in the field of so-called inverse eigenvalue problems. In later published works of other authors, the conjecture has been proven for a number of special cases of matrices with lower sizes. In the general case, however, our conjecture is not proven and remains an open problem for in-depth research.

**[37] Monov, V. Inequalities involving eigenvalues and diagonal entries of a nonnegative matrix, *Comptes rendus de l'Academie bulgare des Sciences*, Tome 63, No 2, pp.189-196, 2010. IF:0.27, Quartile:Q4/SJR: 0.210.**

The article presents results obtained as a follow-up and further development of the studies outlined in publication [36]. Our attention here is specifically focused on the properties of matrices with non-negative elements and the main results in the work are formulated and proved in Theorem 2 and Theorem 3. The result in Theorem 2 presents a family of inequalities between the homogeneous symmetric polynomials of a given order of the eigenvalues of a

non-negative matrix and the corresponding symmetrical polynomials of the diagonal elements of the matrix. The result in Theorem 3 establishes a relation between the power sums of the eigenvalues and the homogeneous symmetric polynomials of the diagonal elements of a non-negative matrix. As a further result (Proposition 1), we have obtained another more direct proof of a result presented in [36]. In conclusion, two areas of possible applications of the results obtained are analyzed and indicated. These are related, on one hand, to the study of another important class of matrices known as M-matrices and, on the other hand, to the analysis of positive dynamic systems.

**[38] Monov, V. On the properties of two matrix products arising in stability theory, Comptes rendus de l'Academie bulgare des Sciences, Tome 63, No 9, pp. 1257-1264, 2010. IF:0.27, Quartile:Q4/SJR: 0.210.**

The object of examination in the presented work are special bi-linear matrix products known as "bialternate product" and "permanentaal bialternite product". Both products are of interest not only in terms of matrix theory but also because of their applications in stability theory, theory of dynamic systems, computation of Hopf bifurcations in systems of ordinary differential equations. In the work, the main algebraic properties of the two products are formulated and their relationship with the well-known Kroneker's product of matrices are established. Equations have been derived concerning the trace and determinant of these matrix products.

**[39] Elsner, L., V. Monov. The bialternate matrix product revisited, Linear Algebra and Its Applications, vol. 434, Issue 4, pp. 1058-1066, 2011. IF:0.972, Quartile: Q1 and Q2/SJR: 0.994.**

This work contains a continuation of the research in publication [38] and, within this framework, the results obtained here substantially extend, deepen and generalize the results of this publication. A unified approach has been developed for the formal mathematical description and investigation of the properties of the bi-linear matrix products known as "bialternate product" and "permanentaal bialternite product". We have established a connection of these matrix products with special classes of matrices (associated and induced), as well as the known Kronecker product and standard matrix multiplication. Derived and proved are algebraic and vector-matrix properties, spectral properties and properties of the matrix trace and determinant of the two products. Their applications in the theory of bifurcations, the theory of stability of Lyapunov and their relation to the so-

called Lyapunov's matrix are pointed out. Possibilities for further generalizations and problems for future research are outlined.

**[42] Tashev, T., V. Monov, Large-Scale Simulation of Uniform Load Traffic for Modeling of Throughput on a Crossbar Switch Node. 8-th Int.Conf. on "Large-Scale Scientific Computations" 6-10 June 2011, Sozopol, Bulgaria. Springer, Lecture Notes in Computer Science (LNCS) Volume 7116 (2012). pp.638-645. SJR: 0.295.**

In modern communication systems, crossbar packet switches route traffic from the input to output where a message packet is transmitted from the source to the destination. The randomly incoming traffic must be controlled and scheduled to eliminate conflict at the crossbar switch. In this paper we have developed a family of patterns for computer modeling of traffic with discrete uniform distribution. The results of computer simulations of the throughput of the switch with the proposed family are presented. The necessary calculations were performed using the computational resources of the IICT-BAS and the CERN network clusters. The results obtained show that the use of the developed traffic model allows to evaluate the effect of large changes in the input buffer on the throughput of the switch.

**[44] Monov, V., B. Sokolov, S. Stoenchev, Grinding in ball mills: Modeling and process control, Cybernetics and Information Technologies, vol. 12, No 2, pp. 51-68, 2012. ISSN 1311-9702. SJR: 0.204.**

Grinding in ball mills is an important technological process that is applied to reduce the size of particles, which may have a different nature and a wide variety of physical, mechanical and chemical characteristics. Typical examples are various ores, minerals, limestone and others. The applications of ball mills are ubiquitous in the mineral, processing and mining industry, metallurgy, cement production, chemical industry, pharmaceuticals and cosmetics, ceramics, etc. The presented article describes the mechanical construction of ball mills, various grinding bodies and the processes of crushing and grinding. From the point of view of process modeling, a kinetic and energy model with the corresponding differential equations describing the material and energy balance during the process are presented and analyzed. For control purposes, the input (control) and output variables, disturbances and corresponding transfer functions are described and an overall characteristic of the problems in the process of control synthesis is made. Detailed analysis of the development and implementation of modern

control strategies such as decentralized and decoupling control, the use of PID controllers and multivariable control is performed. The advantages and drawbacks of the different approaches are analyzed, as well as possibilities for using other modern control methods and information technologies.

**[50] Karastoyanov, D., V. Monov, T. Penchev, New type electromagnetic drive for Braille screen, Third International IEEE Conference on Information Science and Technology, March 23-25 2013, Yangzhou, Jiangsu, China, pp. 178-182, ISBN 978-1-4673-5137-9.**

Standard graphical computer interfaces, based on visual representation and direct object manipulation, make adequate use of the computer quite difficult for people with reduced vision. The problem of providing blind people with computer resources is extremely relevant. The main scientific goal in this publication is the development, design and manufacture a combined tactile/voice interface prototype to make it easier for people with visual impairments to work with computers, regardless of the standard user interface or operating system. For this purpose, a new type of electromagnetic drive of the Braille display needles has been developed. The structure of the proposed display is described, its features are modeled and studied.

**[57] Karastoyanov, D., V. Monov, An advanced technology for renovation of extruding shafts, Proceedings of the International Conference on Mechanical and Industrial Engineering, ICMIE 2013, 15-16 June 2013, Venice, Italy, pp. 407-410, pISSN 2010-376X, eISSN 2010-3778.**

The subject of research in this publication is the technological process of renovation and replacement of the work surface of shafts used in industry and manufacturing for extrusion of non-metallic sheet materials (plexiglass, PVC, packing foil, etc.) Classical technologies for processing of this type of shafts, use coating of the working surface of the shafts with chromium in a galvanic bath. However, it is known that the process is extremely non-ecological and harmful due to the presence of waste cyanide products. The presented publication describes an innovative nanotechnology developed for renovation of the working surface of the shafts, based on non-electric plating of nickel coating with included nanoparticles. The technology is environmentally friendly, resulting in new coating characteristics with increased hardness and durability. Presented and analyzed are the results of experimental tests of the innovative technology with

nanostructured nickel coatings, showing increased wear resistance and contact pressure of the shafts.

**[58] Karastoyanov, D., V. Monov, An intelligent system for knee and ankle rehabilitation, Proceedings of the International Conference on Mechanical and Industrial Engineering, ICMIE 2013, 15-16 June 2013, Venice, Italy, pp. 411-416, pISSN 2010-376X, eISSN 2010-3778.**

The paper examines problems that arise during the post-surgical (orthopedic) rehabilitation of the knee and ankle joint. Existing passive rehabilitation devices as well as the need for intelligent rehabilitation devices and their basic functions are described and analyzed. On this basis the work presents the developed mechatronic rehabilitation system with intelligent functions and possibilities for performing both passive and active rehabilitation. The system monitors patient responses and uses real-time feedback. The main mechanical and electronic components of the system and its main modes of operation are described as well as the necessary medical and technical activities for its realization are pointed out.

**[60] Tashev, T., V. Monov. A Numerical Procedure for Computation of the Upper Bound of the Throughput of a Crossbar Switch Node, Proc. of the International Conference on "Numerical Methods for Scientific Computations and Advanced Applications" (NMSCAA), May 2014, Bansko, Bulgaria, pp.115-118.**

A major problem in communications networks is the need for an accurate assessment of the throughput of the packet switch node depending on the algorithm used and the random nature of the incoming information traffic. In the publication, a numerical procedure has been developed to determine the upper bound of this switch characteristic. We have performed modeling of the switch managed by the PIM-algorithm (Parallel Iterative Matching) and random incoming traffic with discrete probability distribution of Bernoulli. The necessary computations were carried out by means of the computational grid structure of IICT-BAS. The upper bound of the throughput was obtained to be 77.5% when the dimension of the switch tends to infinity.

**[67] Alexandrov, A., V. Monov, Implementation of a service oriented architecture in smart sensor systems integration platform, Proc. of the Third International Conference on Telecommunications and Remote Sensing –**

**ICTRS'14, 26-27 june 2014, Luxembourg, Grand Duchy of Luxembourg, DOI 10.5220/0005422101140120, ISBN 978-989-758-033-8, pp. 114-118, 2014.**

The presented publication describes a concept and software platform with service-oriented architecture developed for integrating heterogeneous data from intelligent sensor systems. The service-oriented technology used provides capabilities for implementation of different functionalities of the platform as services for other applications and users regardless of the service provider. The structure of the platform is built on three layers, the first network layer includes Internet protocols and access to sensor networks and data, the second layer provides tools for data analysis and integration, and the third layer includes user interface and custom applications. The proposed architecture improves the flow of information collected from intelligent sensor systems, enables analysis and integration of heterogeneous data, enhances the reliability of operations, enables additional functionalities to be included at the different levels of the platform.

**[69] Alexandrov, A., V. Monov, ZigBee smart sensor system with distributed data processing, Proc. of the 7-th IEEE Conference Intelligent Systems, Warsaw Poland, Vol. 2, pp. 259-268, September 24-28, 2014., In: Advances in Intelligent Systems and Computing, Springer Vol. 323, ISBN 978-3-319-11309-8, DOI: 10.1007/978-3-319-11310-4\_23. SNIP-2017: 0338.**

The publication presents an intelligent wireless sensor system for monitoring and processing of meteorological data. The system employs an intelligent sensor module developed by the authors and including temperature, humidity and barometric pressure sensors, as well as a built-in GPS co-ordination module. The sensor module is characterized by a flexible architecture, allows operation in several modes, and has the possibility for additional solar power supply. The developed sensor system model is distinguished by a hierarchical topology, the communications in the system being implemented via the ZigBee wireless communication protocol based on the IEEE 802.15.4 standard. An adaptive algorithm for optimizing the energy consumption of sensor modules is proposed to increase the autonomy of the modules. The algorithm is based on a dynamic analysis of measured meteorological data and makes an adaptive change in the time slot for data transmission. As a result of the development, a patent application has been registered:

A.K. Alexandrov, B.B. Monov. "Method and Device for Monitoring and Integration of Data from Meteorological Sensors", Application for Patent for Invention No 112400 of 17.10.2016, Patent Office of the Republic of Bulgaria.

**[70] Futekova, N., V. Monov, Conceptual framework for evaluating the effectiveness of the implementation of enterprise resource planning systems in small and medium-sized enterprises, Economic Alternatives, Issue 3, pp. 117-125, UNWE Publishing Complex, Sofia, 2014, ISSN 1312 – 7462.**

In the area of complex information systems for management of production companies and business enterprises, special interest represent the problems of implementation of Enterprise Resource Planning Systems (ERP) in small and medium enterprises (SMEs) where it is necessary to study the strategies, methods and the critical success factors from the point of view of these enterprises. In this publication, a methodology has been developed to automate and evaluate the process of implementing ERP systems in small and medium-sized enterprises and firms. The methodology includes a set of evaluation criteria and software methods united in their interrelation and consistency. Implementation of the methodology goes through three main stages: 1) analysis of existing business processes and determination of degree of possible automation of the implementation process, 2) selection of functional modules and generation of settings for all layers of the implemented ERP system, and 3) estimation of the economic effect from automated implementation of the system. As a whole, the proposed methodology represents an innovative approach to the successful implementation of ERP projects, enabling both automation and control of the installation process, as well as an assessment of the economic profit of the implementation.

**[71] Futekova, N., V. Monov, Preliminary assessment of the effectiveness of the implementation process of ERP-systems in Bulgarian SMEs, Economic Alternatives, Issue 2, pp.62-76, UNWE Publishing Complex, Sofia, 2015, ISSN 1312 – 7462.**

The development and implementation of software applications in ERP systems is a difficult and responsible task. The proper selection of functional modules as well as a successful running of the process determines to a great extent the success of the future work with the system. For this reason, the implementation process also invariably involves a preliminary survey and study of

enterprises in terms of their needs and their overall activity. The presented paper describes the results of an empirical study aiming to characterize important aspects of the ERP implementation process in Bulgarian SMEs and to determine the need for preliminary evaluation of the efficiency of this process. For this purpose, a survey questionnaire was developed to perform the survey, and a representative sample of small and medium-sized companies was formed in which 55 Bulgarian enterprises were surveyed. The results are summarized, analyzed and conclusions are drawn from the empirical study.

**[72] Futekova, N., V. Monov, Statistical study on the need for a preliminary assessment of the effectiveness of the implementation process of ERP-systems in Bulgarian SMEs, Economic Alternatives, Issue 3, pp. 46-63, UNWE Publishing Complex, Sofia, 2015, ISSN 1312 – 7462.**

The presented publication contains a statistical analysis of the data obtained from the empirical study [71] on a sample of Bulgarian SMEs to establish the need for a preliminary assessment of the efficiency of ERP systems implementation in such enterprises. The analysis is based on one-dimensional and two-dimensional statistical distributions of answers to the survey questions. A graphical representation of the results is given. Some statistical hypotheses have also been formulated and proved and a summary analysis of the results obtained has been made. For the statistical processing and data analysis, the specialized software system IBM SPSS Statistics and the alternative open source GNU PSPSS software were used. The results of the two publications [71] and [72] were used to develop the methodology presented in publication [70] for measuring and assessing of the economic impact of ERP systems implementation in SMEs.

**[74] Monov, V., T. Tashev, A. Alexandrov, Software implementation of several production scheduling algorithms, Proc. of the International Symposium on Business Modeling and Software Design – BMSD'15, 6-8 July 2015, Milan Italy, ISBN 978-989-758-111-3, pp. 205-212, 2015.**

The main subject of research in the theory of scheduling are the problems of optimal allocation of scarce resources in order to carry out planned activities within a specified period of time. The presented publication addresses specifically problems for optimization of production schedules aimed at minimizing the working time of production capacities, while respecting production deadlines and production volumes set out in an enterprise's work schedule. The paper presents program implementation of six algorithms which give solutions of optimization

problems for production scheduling under the conditions of different production constraints and objective functions. The algorithms are programmed as software modules in the program environment of the MATLAB system. Their input-output parameters and basic characteristics are described and their work is illustrated by numerical examples. The developed user interface unites in a single program system algorithms for inventory control and the optimization algorithms for production scheduling in the present work.

**[78] Kolchakov, K., V. Monov, Adaptive algorithm for management by weight coefficients of the traffic in crossbar commutator, Int. Journal “Information Models and Analyses”, vol. 4, Issue 1, pp. 53-60, ISSN 1314-6416(printed), 1314-6432(online), 2015.**

The problem of synthesis of a conflict-free schedule for a packet crossbar switch in communication systems refers to the class of NP-hard problems (nondeterministic polynomial time problems). There are two types of conflict situations for the switch: 1) when two or more packet data sources transmit messages to the same receiver and 2) when one source transmits packet messages to two or more receivers. In this article we have developed an adaptive algorithm for conflict-free traffic management by determining appropriate weighting coefficients for the incoming requests. In the algorithm, the higher weight determines a higher priority for executing the request, so that by an adaptive change of weights it is possible to avoid conflicting situations. A software model of the algorithm was developed in the computing environment of the MATLAB programming system. Computer simulations have been carried out showing the functionality of the algorithm. An optimized variant of the algorithm with a reduction in the number of weighting factors is also proposed.

**[79] Kolchakov, K., V. Monov, A comparison study of an algorithm for non-conflict schedule with diagonal activation of joint sub matrices in a large scale switching matrix, Information Technologies and Control, vol. 2, pp. 31-35, ISSN 1312-2622(printed), 2367-5357(online), 2015.**

In the presented publication, an algorithm for synthesis of a conflict-free schedule of the requests in a packet crossbar switch has been developed and studied. The operation of the switch is determined by the so-called connection matrix and by using this matrix, the proposed algorithm is accomplished in several steps. The first step includes execution of conflict-free queries in the diagonal submatrices of the connection matrix. At each subsequent step, the algorithm

executes queries determined by pairs of submatrices in diagonals parallel to the main diagonal of the connection matrix. A software model of the algorithm has been developed and its performance has been examined for large sizes of the connection matrix. A comparison is made with algorithms of the same class, and relations are established between performance, execution time and required computer memory depending on the size of the connection matrix.

**[85] Kolchakov, K., Monov, V. Algorithm for non-conflict schedule in sub matrices optimal in terms of performance and memory. Information Technologies and Control, No 2, pp. 2-6, 2017, ISSN:1312-2622, On-line ISSN 2367-5357, DOI:10.1515/itc-2017-0006.**

In this publication, we present a comparative study of six algorithms for synthesis of a conflict-free schedule for traffic management in a packet crossbar switch in communication networks and systems. The algorithms investigated have been developed in previous author's publications and implement different approaches to ensure the non-conflict execution of incoming queries and switching management. The software implementation of the algorithms, as well as the results of the performed numerical simulations with them are presented. For comparison, the results are visualized in tabular and graphical form. We have established an algorithm optimal with respect to performance (Algorithm with joint diagonals activations, AJDA) and an algorithm optimal with respect to required computer memory (Adaptive algorithm for management by weight coefficient, AAM). A minimal difference between the two algorithms is established in regard to required memory, so that the first of these algorithms could be considered as preferable from the point of view of performance and required computational resources.

**[96] Alexandrov A., Monov V. (2018) Method for Adaptive Node Clustering in AD HOC Wireless Sensor Networks. In: Vishnevskiy V., Kozyrev D. (eds) Distributed Computer and Communication Networks. DCCN 2018, pp 257-263. Springer book series "Communications in Computer and Information Science", CCIS, Vol. 919, Springer, Cham. Print ISBN 978-3-319-99446-8. SJR:0.170.**

The presented publication addresses the problem of clustering of sensor nodes in wireless sensor networks. The study is based on the known algorithm for adjacent sensor nodes analysis and ad-hoc clustering WCA (Weighted Clustering Algorithm). In the work, the original version of the WCA has been modified and

upgraded by adding new parameters and equations relating to the quality of the communication links of the individual sensor nodes. The proposed new approach allows for a significantly faster and more energy-efficient process of distribution of sensor nodes. The method is characterized by several key features. Generating clusters in the network is based primarily on the quality of connections between sensor nodes and not on the distance between them. This significantly reduces the risk of network failures due to increased noise levels in the connections. The determination of cluster heads as well as the topology of the network have been optimized as compared to the original algorithm. As a result, a better information transmission and energy efficient communication between nodes is achieved.

**[97] Alexandrov, A., Monov, V. Q-Learning based model of node transmission power management in WSN, Proc. of the International Conference “Big Data, Knowledge and Control Systems Engineering BdKCSE’2018”, November 2018, Sofia, Bulgaria, pp. 15-22.**

In this work we have studied the possibility for employing machine learning methods to manage communications and optimize energy consumption in wireless sensor networks. For this purpose, a model of a wireless sensor node based on an artificial neural network of multilayer perceptron type is developed. Parameters of the input, hidden, and output layers of the network are defined and for network training a method of Reinforcement Learning known as Q-learning is used. The proposed approach allows for efficient management of energy consumption in the information transmission process, thus optimizing resource usage and extending the shelf life of battery-powered wireless network sensors.