The Fourth International Conference on Network Analysis NET 2014

May 12-13, 2014

Center for Applied optimization (CAO),
University of Florida, USA

Laboratory of Algorithms and Technologies for Networks Analysis (LATNA),
Higher School of Economics, Nizhny Novgorod, Russia

Monday, May 12

Room 209 HSE, 136 Rodionova Str.

09:00-09:30 Panos M. Pardalos

The Fourth International Conference on Network Analysis NET 2014

09:30-10:20 Nenad Mladenovic

Skewed general VNS for the maximally diverse grouping and clique partitioning problems on the network

10:20-10:40 Coffee Break

10:40-11:30 Leonidas Pitsoulis

Matroids, Graphs and Optimization

11:30-12:30 Session 1

Vladimir D. Matveenko
Role of Types of Nodes in a Network Game with Knowledge Externalities

Vyacheslav V. Chistyakov
The threshold decision making

Patrick Muldowney
A New Perspective on Kolmogorov's Theory of Probability

12:30-14:00 Lunch Break

14:00-14:50 Theodore B. Trafalis

Kernel Methods with Imbalanced Data and Applications to Weather Prediction

14:50-15:10 Coffee Break

15:10-16:10 Session 2

Dmitriy S. Malyshev
The complexity of the coloring problems for hereditary classes with forbidden induced subgraphs of a small size

Dmitriy V. Gribanov
Flatness Theorem Analogs for Polytopes With Bounden Minors of Constraints Matrix

Dmitriy B. Mokeev
Konig graphs for 4-paths

16:10-16:30 Coffee Break

16:30-17:30 Session 3

Ivan Grechikhin
How independent are the stocks in the maximal independent set of a market graph

Larisa Komosko
A fast greedy sequential heuristic for the vertex coloring problem

Anton Kocheturov
Methods based on Jensen-Shannon Divergence for Change-Point Detection in EEG Records

Grigoriy Bautin
Robustness of sign correlation in market network analysis

Tuesday, May 13

Room 209 HSE, 136 Rodionova Str.

09:30-10:20 Mauricio G. C. Resende

A biased random-key genetic algorithm for a prize-collecting directed Steiner forest network design problem

10:20-10:40 Coffee Break

10:40-11:30 Vladimir Boginski

Analyzing Cohesive Clusters in Complex Networks

11:30-12:30 Session 4

Petr Koldanov
Different measures of similarity for multivariate elliptically contoured distributions

Elena Zamaraeva
On teaching set of k*-threshold functions*

Alexey Nikolaev
Reusing the same coloring in the child nodes of the search tree for the maximum clique problem

Irina Utkina
A branch-and-bound algorithm for the cell formation problem

12:30-12:50 Coffee Break

12:50-13:50 Session 5

Stanislav Vlasov
Conferences co-participation networks of SME

Tatyana Poletaeva
Semantic Solution for Seamless Data Exchange in Supply Networks

Alexander Ponomarenko
The Web without search engines

Ludmila Egorova
The effectiveness of different trading strategies for price-takers

Skewed general VNS for the maximally diverse grouping and clique partitioning problems on the network

Nenad Mladenovic
LAMIH, University of Valenciennes, France

Joint work with J. Brimberg and D. Urosevic

The maximally diverse grouping problem (MDGP) requires finding a partition of a given set of elements into a fixed number of mutually disjoint subsets (or groups) in order to maximize the overall diversity between elements of the same group. We develop new variant of variable neighbourhood search based heuristic for solving the problem. Based on extensive computational experience, it appears that our new heuristic outperforms the current state of the art heuristic. Moreover, the best know solutions have been improved on 531 out of 540 test instances from the literature. Then we show that the Clique partitioning problem (CPP) can be reformulated in an equivalent form as the Maximally Diverse Grouping Problem. We then modify a skewed general variable neighbourhood search heuristic (SGVNS) that was first developed to solve the MDGP. Similarly as with the MDGP, significant improvements over the state of the art are obtained when SGVNS is tested on large scale instances. This further confirms the usefulness of a combined approach of diversification afforded with skewed VNS and intensification afforded with the local search in general VNS. Finally, we show that CPP may be used to identify communities on social network instances. The results are compared with 'ratio/cut' and modularity criteria.

Matroids, Graphs and Optimization

Leonidas Pitsoulis
Department of Mathematical, Physical & Computational Sciences, Engineering School, Aristotle University of Thessaloniki, Greece

Matroid theory originated from the attempt to combine the combinatorial and algebraic aspects of graphs and matrices into a common abstract notion. Considering that graphs constitute a natural framework for most combinatorial optimization problems, it is natural to expect that a generalization of graphs will provide a unified abstract setting upon which many combinatorial optimization problem properties can be examined. In this talk we will present some of the most important algorithmic and structural connections between matroids and optimization, as well as recent advances and open problems in the area.

Kernel Methods with Imbalanced Data and Applications to Weather Prediction

Theodore B. Trafalis
School of Industrial and Systems Engineering, University of Oklahoma, USA

The main objective of this talk is to present recent developments in the applications of kernel methods and Support Vector Machines (SVMs) to imbalanced data related to weather prediction. I will also discuss how kernel methods can be used to uncover physically meaningful, predictive patterns in weather radar data that alert to severe weather before the severe weather occurs. Specific indices related to the analysis of severe weather data (for example tornado data) using kernel methods will be also discussed. In addition a family of learning algorithms, motivated by Support Vector Machines, capable of replacing traditional methods for assimilating data and generating forecasts, without requiring the assumptions made by the assimilation methods (Kalman filters) and an application of kernel methods to processing the states of a Quasi-Geostrophic (QG) numerical model will be presented. Extensions of those techniques to other areas of applications will be investigated.

A biased random-key genetic algorithm for a prize-collecting directed Steiner forest network design problem

Mauricio G. C. Resende, Robert D. Doverspike, Ken Reichmann, Rakesh Sinha, Max Zhang
AT&T Labs Research, USA

Carlos de Andrade, Flávio K. Miyazawa
University of Campinas, Brazil

We model a wireless backhaul network design problem as a prize-collecting directed Steiner forest problem. In this problem we are given a set of demand points where wireless traffic originates, along with the amount of traffic, a set of backbone access points, and we want to build a wireless backhaul network to transport the traffic from the demand points to the backbone by using equipment installed on a set of given utility poles. LTE and Wi-Fi are used to capture traffic from demand points and backhaul transmission equipment is used to transmit traffic between utility poles and between utility poles and backbone access points. There are many types of constraints imposed on the design, e.g., maximum transmission equipment coverage, maximum number of hops from the demand point to the backbone node, maximum node in-degree, and link capacity on the sum of flow into a node and the traffic captured by the LTE and Wi-Fi equipment at the node. The objective is to maximize the difference between the monetary value of the backhauled traffic and the cost of building and operating the network. We present a biased random-key genetic algorithm to solve this problem.

Analyzing Cohesive Clusters in Complex Networks

Vladimir Boginski
Department of Industrial and Systems Engineering, University of Florida, USA

Networks are ubiquitous in the modern world. Many natural and man-made complex systems and processes can be modeled as networks, where nodes (vertices) are elements of a system, and links (edges) represent interactions between these elements. Notable examples of such systems include the Internet, wireless communications, power grids, natural ecosystems, biological interactions, and social networks, among other applications. One important issue of interest to many such applications is finding large clusters, or ‘‘tightly knit’’ (“cohesive”) subsets of vertices. The ideal description of a cluster of similar elements is given by the concept of a clique (complete subgraph), defined as a subset of vertices any two of which are connected by an edge. Moreover, in the context of physical networks, cliques are very resilient to node/link failures (the property sometimes referred to as “attack tolerance”). However, cliques are often overly restrictive in practical settings, because they may be too expensive or infeasible to construct, and they do not provide much modeling flexibility (i.e., a clique with a few missing edges would for many practical purposes still be a sufficiently “tight” cluster, but the classical clique model does not capture this adjustment). Therefore, more flexible models of cohesive network clusters, referred to as clique relaxations, have been introduced. These models “relax” certain characteristics of a clique, such as edge density (quasi-clique), minimum node degree (k-plex), diameter (k-club), etc. In this presentation, we will discuss combinatorial optimization problems dealing with: 1) identifying the largest cohesive/robust cluster (clique relaxation) in a given network; 2) optimal design/augmentation of a network so that it would form a robust cluster. Recent developments in both theoretical and computational aspects of these areas will be presented.

Robustness of sign correlation in market network analysis

Grigory A. Bautin
LATNA, National Research University Higher School of Economics, Russia

Financial market can be modeled as network represented by a complete weighted graph. Different subgraphs of this graph (minimum spanning tree, market graph and others) give important information on the network. In the present paper we study how the choice of measure of interaction between stocks influences the statistical uncertainty of the subgraphs. We show that sign correlation is robust measure of interaction in contrast with Pearson correlation widely used in market network analysis. This gives a possibility to get more precise information on stock market from observations.

The threshold decision making

Vyacheslav V. Chistyakov
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Basing on the leximin preference order, we consider the threshold preference relation on the set X of alternatives, each of which is characterized by an n-dimensional vector (n>2) with integer components varying between 1 and m (m>2). We determine explicitly in terms of binomial coefficients the unique utility function, which in addition maps the set X onto the natural `interval' $\{1,2,\ldots,|X_1|\}$, where $|X_1|$ is the cardinality of the quotient set $X_1 = X/I$ of X with respect to the indifference relation I on X induced by the threshold preference order. This permits us to evaluate all equivalence classes and indifference classes of the threshold order on X, present an algorithm of ordering the monotone representatives of indifference classes, and restore the indifference class of an alternative via its ordinal number with respect to the threshold preference order.

The effectiveness of different trading strategies for price-takers

Ludmila G. Egorova
LATNA, National Research University Higher School of Economics, Russia

Simulation models of the stock exchange are developed to explore the dependence between a trader's ability to predict future price movements and her wealth and probability of bankruptcy, to analyze the consequences of margin trading with different leverage rates and to compare different investment strategies for small traders. We show that in the absence of margin trading the rate of successful predictions should be slightly higher than 50% to guarantee with high probability that the final wealth is greater than the initial and to assure very little probability of bankruptcy, and such a small value explains why so many people try to trade on the stock exchange. However if trader uses margin trading, this rate should be much higher and high rate leads to the risk of excessive losses.

How independent are the stocks in the maximal independent set of market graph.

Ivan Grechikhin
LATNA, National Research University Higher School of Economics, Russia

The problem of testing hypothesis for independence of given set of stocks is considered. Independence is defined from probability theory point of view. Two tests of independence are compared. First test is classic maximum likelihood test based on determinant of sample covariance matrix. Second test is pair wise test used in network theory. This test is based on testing for independence of each pair of stocks by Pearson correlation test. The main result is: maximum likelihood test is more powerful for wide class of alternatives but for some specific alternative the Pearson test is more powerful. Some examples are given.

Flatness Theorem Analogs for Polytopes With Bounden Minors of Constraints Matrix

Dmitriy V. Gribanov
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National Research University Lobachevsky State University of Nizhniy Novgorod, Russia

Let A be an $m \times n$ integral matrix of the rank n, we say that A has bounded minors if the maximum of the absolute values of the $n \times n$ minors is at most k, we will call these matrices as *k-modular*. We investigate an integer program $\max\{c'x : Ax \le b, x \in Z^n\}$, where A is *k-modular*.

We say that A is *almost unimodular* if it is 2-modular and the absolute values of its $(n-1)\times(n-1)$ minors are at most 1 (we following terminology of [4]). We also refer 2-modular matrices to as *bimodular* (we following terminology of [18]). We say that A is *strict k-modular* if the absolute values of its $n \times n$ minors are from the set $\{0, k, -k\}$.

We try to investigate the integer width of empty lattice polytope (see [2, 3, 5, 10, 13, 14]) and find algorithms for the effective searching of the integer point in a polytope if it's large enough.

In previous works (see [6, 7]) we make some investigations on the integer width of the lattice free polytopes with *strict k-modular* constraints matrices and on width of the lattice free simplices with *k-modular* constraints matrices. More precisely, we proved theorems, that allows you to effectively search integer point in polytope if its integer width is large enough.

In this work we use the analog of the classical integer width of a polytope. This analog uses different normalizations on the direction functional for computing minimal width of a polytope. Using this definition we will prove analogs of the classical flatness theorem. Our main parameters will be eigenvalues and minors of constraints matrix of the polytope.

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Methods based on Jensen-Shannon divergence for change-point detection in EEG records

Anton Kocheturov
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Segmentation of EEG records is an essential step of the human brain analysis based on its electrical activity. It can be used as a preprocessing technique for the further analysis or as an analyzing tool itself showing the number and lengths of the statistically stationary segments which can reveal the nature of processes in the brain. Change-point detection is NP-hard problem since we do not know beforehand the number of change points. Thus due to the huge size of the EEG sequences we use a heuristic method to detect the change points. Our method is based on the recursive Jensen-Shannon segmentation scheme proposed by Bernaola-Galvan et al. in 1996. Our method provides better change-points detection comparing with other techniques and performs faster either on generated time series or on real EEG records because of our speed improvements.

Different measures of similarity for multivariate elliptically contoured distributions

Petr A. Koldanov
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The connection between Pearson correlation and sign correlation is investigated for elliptically contoured distributions. A mixture of multivariate normal distribution and multivariate Student distribution is considered as a model of simultaneous behavior of stock returns of financial market. Stability of statistical estimations of Pearson and sign correlations is compared for the model. Some structural characteristics of complete weighted graph are considered. Construction problem of these characteristics as multiple decision statistical procedure is formulated. Stability of such procedures is measured by conditional risk. It is shown that statistical procedures based on sign correlation are stable with respect to parameters of mixture of multivariate normal distribution and multivariate Student distribution.

A fast greedy sequential heuristic for the vertex coloring problem

Larisa Komosko
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In this paper a fast greedy sequential heuristic for the vertex coloring problem is presented. Its high performance is based on two features. First, after coloring the current vertex we mark its color as forbidden for its neighbors. Second, we calculate a color for the current vertex and forbid it for its neighbors by means of bitwise operations with adjacency and color matrices. In the matrix of forbidden colors c ij =0 if vertex j can be colored in color i and c ij =1 if color i is forbidden for it. In comparison with the classical greedy heuristic the speedup reaches 28 times on DIMACS instances.

The complexity of the coloring problems for hereditary classes with forbidden induced subgraphs of a small size

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A *class of graphs* is a set of simple unlabelled graphs. A class of graphs is called *hereditary* if it is closed under deletions of vertices. It is well known that a hereditary (and only hereditary) class can be defined by a set of its forbidden induced subgraphs. The coloring and *k*-coloring problems are classical NP-complete problems on graphs. Complete and partial classifications are known for the complexity of these problems in the family of hereditary classes with small forbidden structures. I will give complete and partial complexity dichotomies for the problems and hereditary classes with a larger size of prohibitions.

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Role of Types of Nodes in a Network Game with Knowledge Externalities

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Let $\Gamma = (M, N)$ be a non-oriented connected graph. If the set of nodes is decomposed into disjoint subsets, $M = M_1 \cup ... \cup M_J$, then each node $i \in M$ can be characterized by the vector $g_i = (g_i^1, ..., g_i^J)$ of the numbers of its neighbor-nodes belonging the subsets. Evidently, such decompositions exist for which in each subset M_j all the nodes $i \in M_j$ possess the same vectors $g_i = g(j)$ of the numbers of neighbors. Moreover, there exists the decomposition with the maximal number of subsets. We refer to the subsets M_j in this maximal decomposition as *types* of nodes. We describe an algorithm of decomposition of the set of nodes into types.

We study an economic model in which the types of nodes have essential meaning. Our model is network generalization of a simple two-period endogenous growth model with knowledge externalities by P. Romer (Journal of Political Economy, 1986). In our model there is a network consisting of cities inhabited by identical consumers characterized by a twice differentiable, increasing, strictly concave utility function $U(c_1^i, c_2^i)$, where c_1^i, c_2^i are per capita consumptions at two time periods, and $i = 1,...,|M|$ is a city. Each consumer is endowed by initial stock *e* of good at period 1. A research technology produces knowledge k_i (per capita) one to one from forgone consumption. Material production at period 2 is described by production function $F(k_i, K_i)$, which depends on the knowledge, k_i, in the city as well as on the externality created by the sum of knowledge, K_i, in the neighbor cities (including the city *i* itself). Function F is assumed to be convex in k_i for each K_i.

We show that the equilibrium behavior depends only on the types of nodes. Networks of different size but with similar types possess similar equilibria. We study in details the case of

$$U(c_1, c_2) = \frac{\{c_1(e - ac_1) + bc_2\}^{1-\sigma}}{1-\sigma}, \text{ where } 0 < a < \frac{1}{2},\ b > 0,\ 0 < \sigma < 1;$$

$$F(k, K) = BkK, \text{ where } B > 0.$$

We find full solutions for the networks with 1 and with 2 types. We provide examples of various network structures.

Konig graphs for 4-paths

Dmitriy B. Mokeev
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National Research University Lobachevky State University of Nizhniy Novgorod, Russia

Let $\mathcal{X}$ be a class of graphs. Given a graph G, we define the *covering number* of G with respect to the class $\mathcal{X}$ as minimum carginality of a set of vertices meeting every induced $\mathcal{X}$-subgraph of G. The *packing number* of G with respect to the class $\mathcal{X}$ is defined as a maximum number of vertex-disjoint induced $\mathcal{X}$-subgraphs in G.

A *König graph for* $\mathcal{X}$ is a graph in which every induced subgraph has the property that the packing number with respect to $\mathcal{X}$ is equal to the corresponding covering number. The class of all König graphs for set $\mathcal{X}$ is denoted as $\mathcal{K}(\mathcal{X})$. If $\mathcal{X}$ consists of a single graph H, then we will talk about König graphs for H, etc.

Being formulated as integer linear programming problem, the problems of $\mathcal{X}$-packing and $\mathcal{X}$-covering form a pair of dual problems. So König graphs are graphs such that for any induced subgraph there is no duality gap. In this regard König graphs are similar to perfect graphs having the same property with respect to another pair of dual problems (vertex coloring and maximum clique), which facilitates the efficient solution of these problems for perfect graphs.

$\mathcal{K}(\mathcal{X})$ is *hereditary* class for every $\mathcal{X}$. It means that it is closed under deletions of vertices. It is known that a hereditary (and only hereditary) class can be defined by a set of its *forbidden induced subgraphs*.

One of such definition was described in 2003 by G. Ding, Z. Xu and W Zang. They described all forbidden induced subgraphs for class of graphs which is equal to $\mathcal{K}(\mathcal{C})$, where $\mathcal{C}$ is a set of all simple cycles.

Another exhaustive description for set of forbidden induced subgraphs was obtained for class $\mathcal{K}(P_3)$. In addition polynomial recognition algorithm for this class and polynomial algorithm of finding P_3-packing were given.

The aim of this work is to characterize the class $\mathcal{K}(P_4)$. There are two approaches to description of this class. One of them is constructive: we show how to construct a graph of given class by operations of edge subdivision and replacement of vertices and terminal paths with cographs.
In another approach we look for a standard description of hereditary class by forbidden subgraphs. The found set of forbidden subgraphs consists of 12 infinite families and 62 individual graphs also. It is unknown whether it is a complete set of minimal forbidden subgraphs for $\mathcal{K}(P_4)$, but we suppose that this is so

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A New Perspective on Kolmogorov's Theory of Probability

Patrick Muldowney
University of Ulster, Northern Ireland

Kolmogorov's theory of probability is one of the profound success stories of twentieth century mathematics. Its success was founded on advances in the theory of integration associated with Henri Lebesgue, which, in turn, are based on the mathematical theory of measure.

But twentieth century probability theory is constrained by certain features of the Lebesgue integral. Lebesgue integration---and Kolmogorov's theory of probability---cannot safely be used without first mastering the underlying theory of measure, which is a subtle and difficult subject.

Furthermore, in Lebesgue integration, as in the Riemann integration that it superseded, a function is integrable only if its absolute value is integrable. Consequently, some perfectly straightforward functions, which happen to be highly oscillatory, cannot be integrated by Lebesgue's method. This limitation meant, for instance, that Richard Feynman's mid-twentieth century discoveries in quantum mechanics, including the theory of light for which he received the Nobel Prize, could not be expressed in probability terms to which his theory bears a strong formal resemblance.

A further limitation is manifested in the It\^o calculus used in financial mathematics and the theory of communication. This is because the Lebesgue version of stochastic calculus is relatively complicated and difficult to apply in practice.

These limitations can be overcome if, instead of Lebesgue integration, the theory of probability is formulated in terms of Riemann-type integrals which are generally easier to understand than Lebesgue integrals.

In the 1950s a new method of integration, using Riemann sums, was discovered independently by Ralph Henstock and Jaroslav Kurzweil. The best-known version is the Henstock--Kurzweil integral, also called the Riemann-complete integral.

Every Riemann integrable function is also Lebesgue integrable. Historically, Lebesgue integration is said to supersede Riemann integration. But every Lebesgue integrable function is also Riemann-complete integrable. So Riemann-complete integration can be said to supersede Lebesgue integration. Also, Riemann-complete integration can deal with important functions which, though simple to express, are highly oscillatory and therefore beyond the scope of the Lebesgue method.

This fact opens up new vistas in the the formulation of probability theory and its real-world applications.

Reusing the same coloring in the child nodes of the search tree for the maximum clique problem

Alexey Nikolaev
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In this talk we present a new approach to reduce the computational time spent on colouring in one of the recent branch-and-bound algorithms for the maximum clique problem. In this algorithm candidates to the maximum clique are coloured in each search tree node. We suggest that the colouring computed in the parent node is reused for the child nodes when it will not lead to many new branches. So we reuse the same colouring only in the nodes for which the upper bound is greater than the current best solution only by 1 or 2. The obtained increase in performance reaches 60% on benchmark instances

Semantic Solution for Seamless Data Exchange in Supply Networks

Elena Andreeva[1], Tatiana Poletaeva[1], Habib Abdulrab[2], Eduard Babkin[1]

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This paper proposes the semantic solution for data exchange in dynamically changing supply networks. These networks appear as a result of interactions of autonomous partners that act according to their own plans, goals, and strategies. Permanent participants can form stable connections of the network. However, networks are usually open for new participants. Despite on dynamic nature of supply networks, there is a necessity to manage their efficiency. The first step in this direction is proper data exchange, which leads to transparency of networks and speeds up interactions of their participants. Despite plenty of data standards, there is a lack of approaches to data modeling allowed the seamless extension and sharing of knowledge within supply networks. This paper introduces a new ontological framework for data models of supply networks based on formal knowledge of organizations – the Enterprise Ontology, as well as on consistent theory for data modeling – the Object Paradigm. At the first part of the paper, chosen philosophical and logical approaches to data modeling are explained and justified. Then, basic information patterns applicable for modeling of supply networks are explained. Finally, for better understanding of the benefits of proposed ontological framework, we exemplify the use of the ontology for creation of the information system aimed for the diagnosis of traceability problems in supply processes.

The Web without search engines

Alexander Ponomarenko
Laboratory LATNA, National Research University Higher School of Economics, Russia

A classic approach for the information retrieval in the Web is to use search engines which provide access to the pre-built index. However the Web is huge, so already now the search engines can index only a small part of the Web with continues to grow with the exponential speed. Also index permanently contains outdated information because the Web constantly changing and index should be rebuilt every time.

More over the classic approach makes us totally dependent on the search engines, so they can provide any information to us what they want based on commercial or political interests.

Fortunately there is another approach. Information can be retrieved by surfing through the Web graph in the direction of increasing relevance to the query.

But the questions appear “Is it possible to find information in such way?”, “How fast?”, “Is it possible to construct graph where information can be founded by greedy algorithm and can be founded fast with the high probability?”

In this talk we give the answers for these questions and present an algorithm of constructing of such graph. So we present a way how the Web can be organized so that information retrieval can be performed efficiently without traditional search engines.

A branch-and-bound algorithm for the cell formation problem

Irina Utkina
Laboratory LATNA, National Research University Higher School of Economics, Russia

In this talk we consider the cell formation problem with a fractional objective function. This problem consists in finding the optimal partitioning of machines and parts into groups (production cells, or shops), in order to minimize the inter-cell movement of parts from one cell to another and to maximize intra-cell processing operations. The problem belongs to the class of NP-hard combinatorial optimization problems. The number of feasible solutions of the problem is growing very rapidly with size (the number of machines and parts). In this talk we present a new branch-and-bound algorithm for the cell formation problem. We suggest a novel way of branching, and also an efficient upper bound, which allows us to reduce the search tree size significantly.

Conferences co-participation networks of SME

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There is no doubt that if you happen to visit some interesting event, like a conference, it is very likely that you will find yourself inspired, full of energy and new ideas. Moreover, chance encounters at such events often lead to long-term professional collaboration (e.g., Berends, van Burg, & van Raaij, 2011; Kreiner & Schultz, 1993). Events like trade shows or international conferences can also be seen as "temporary clusters" because they bring together people from various organisations from all over the world and similar to permanent clusters like Silicon Valley provide rich opportunities for intensive interaction, knowledge exchange, learning and ideas variation. While it is common knowledge that most innovative firms are located in clusters, little is known about the role of temporary form of clustering in innovation networks and its dynamics. Following this logic, in this study, I test a number of hypotheses on the relationship between company's participation at scientific and professional events, diversity of participation, position in co-participation networks (Stam, 2010) and its subsequent innovation performance. I use archival data from conference proceedings of firms in electronics industry (1992-2012) and their patent portfolios (number patents and its citations), which is considered a proper operationalization of innovation performance for this industry (Hagedoorn & Cloodt, 2003). Preliminary findings reveal that firms which follow a certain strategy in terms of diversity of events participation and positioning in co-participation networks of organizations and knowledge communities are likely to be more successful in subsequent innovation performance. These results contribute to the literature on temporary forms of clustering and informal networks formation in high technology industries.

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On teaching set of *k*-threshold functions

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A function that maps the *n*-valued d-dimensional hypecube (domain) to {0;1} is called threshold if there exists a hyperplane separating the set of points where the function is equal to 0 from the points where the function is equal to 1. We study *k*-threshold functions, i.e. functions that can be represented as a conjunction of *k*-threshold functions. We investigate a teaching set *T* of *k*-threshold function, i.e. a subset of the domain such that no other *k*-threshold function agrees with the given function on the whole *T*. It's known that the minimal teaching set for threshold function is unique and is equal to the set of its essential points. We prove that the set of essential points doesn't specify *k*-threshold function in general case. Moreover *k*-threshold function can have more than one minimal teaching sets.

The most complete results are obtained for 2-threshold functions and *d=2*. For example, it's proved that the number of minimal teaching sets for *d=2, k=2* can grow as $\theta(n)$. Also there exists partition of the class of 2-threshold functions for *d=2* into subclasses depending on the function structure. Structure of teaching set, upper and, in some cases, lower bounds for cardinality of minimal teaching sets is obtained for every subclass. Depending on the function structure the cardinality of its minimal teaching sets can grow as $\theta(n^2)$, $O(n)$ or constant.