3rd Yalta Optimization Conference "Network Science"

August 2-4, 2010

Yalta, Ukraine

Organizers: Sergiy Butenko (Texas A&M University, USA)
Oleg Prokopyev (University of Pittsburgh, USA)
Volodymyr P. Shylo (Glushkov Institute of Cybernetics, Ukraine)

V.M. Glushkov Institute of Cybernetics
OF NATIONAL ACADEMY OF SCIENCES OF UKRAINE

PROGRAM

Welcome from the Organizers

Dear Colleague,
We are pleased to welcome you in Yalta, one of the world's most famous historical conference sites, for 3rd Yalta Optimization Conference. The main theme of the conference this year is "Network Science." We hope that this event will provide an excellent forum for exchange of ideas, sharing the latest advances and challenges in theoretical and applied optimization, and discussing opportunities for future international collaborations on research and education in these areas. Enjoy the conference and your stay in Yalta!

Conference Organizers

Sergiy Butenko
Texas A&M University, USA
Oleg Prokopyev
University of Pittsburgh, USA
Volodymyr P. Shylo
Glushkov Institute of Cybernetics, Ukraine

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Acknowledgements

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Conference Schedule

Monday, August 2

08:00-13:00 Registration ("Visla", 16th floor)
08:30-10:30 Session M1: Network Science
- Anna Nagurney (Keynote)
- Pavlo Krokhmal
- Botond Molnár

10:30-11:00 Coffee Break
11:00-12:30 Session M2: Global Optimization
- Mikhail Posypkin
- Oleg Shcherbina
- Ilias Kotsireas

12:30-14:00 Lunch ("Ai-Petri")
19:00-21:00 Banquet Dinner ("Ai-Petri")

Tuesday, August 3

08:00-13:00 Registration
08:30-10:30 Session T1: Optimization Methods
- Yaroslav Sergeyev (Keynote)
- Oleksandra Yezerska
- Oleksii Mostovyi

10:30-11:00 Coffee Break
11:00-13:00 Session T2: Networks Everywhere
- Volodymyr Shylo
- Anurag Verma
- Julio Rojas-Mora
- Alex Savenkov

Wednesday, August 4

08:30-10:30 Session W1: Transportation and Logistics
- Oleg Burdakov (Keynote)
- Joaquín Pacheco
- Vasyl Gorbachuk

10:30-11:00 Coffee Break
11:00-13:00 Session W2: Networks Everywhere Again
- Dmytro Korenkevych
- Zeynep Ertem
- Alla Kammerdiner
- Serdar Karademir

Useful Information

- Wireless internet cards can be purchased in the hotel's lobby.
- The dress code for all the conference activities is casual.

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Session M1: Network Science

Monday, 8:30-11:00

Chair: Oleg Prokopyev

KEYNOTE **Fragile Networks: Identifying Vulnerabilities and Synergies in an Uncertain World**, Anna Nagurney, *John F. Smith Memorial Professor, Director - Virtual Center for Supernetworks, Department of Finance and Operations Management, Isenberg School of Management, University of Massachusetts Amherst, Amherst, MA, USA*. E-mail: nagurney@gbfin.umass.edu.

The growing number of disasters globally has dramatically demonstrated the dependence of our economies and societies on critical infrastructure networks. At the same time, the deterioration of the infrastructure from transportation and logistical networks to electric power networks due to inadequate maintenance and development as well as to climate change, has resulted in large societal and individual user costs. This talk will focus on recently introduced mathematically rigorous and computer-based tools for the assessment of network efficiency and robustness, along with vulnerability analysis. The analysis is done through the prism of distinct behavioral principles, coupled with the network topologies, the demand for resources, and the resulting flows and induced costs. The concepts will be illustrated in the context of congested transportation networks, supply chains under disruptions, financial networks, and dynamic networks such as the Internet and electric power networks. We will further explore the connections between transportation networks and different network systems and will quantify synergies associated with network integration, ranging from corporate mergers and acquisitions to collaboration among humanitarian organizations.

Random Combinatorial Optimization Problems on Hypergraph Matchings, Pavlo Krokhmal, *Department of Mechanical and Industrial Engineering, University of Iowa, Iowa City, IA, USA*. E-mail: krokhmal@engineering.uiowa.edu.

We consider a class of discrete optimization problems where the underlying combinatorial structure is based on hypergraph matchings, which generalize the well-known problems on bipartite graph matchings, such as the Linear Assignment Problems, Quadratic Assignment Problems, etc., and are also known as multidimensional assignment problems (MAPs). Properties of large-scale randomized instances of MAPs are investigated under assumption that their assignment costs are iid random variables. In particular, we consider linear and quadratic problems with sum and bottleneck objectives. For a broad class of probability distributions, we demonstrate that optimal values of random MAPs converge in L1 and almost surely as problem size increases, and establish the corresponding convergence rates. Computational properties of large-scale randomized MAPs are discussed. Using the results of the limiting case analysis, we introduce polynomial algorithms that produce solutions converging to optimality almost surely, and establish the corresponding convergence rates.

Renormalization group approach to complex clustering on networks, Melinda Varga, Botond Molnár, and Zoltán Néda, *Department of Theoretical and Computational Physics, Babeş-Bolyai University, str. Kogălniceanu 1, RO-400084, Cluj-Napoca, Romania*. Email: molnarb14@gmail.com.

The problem of correlation clustering is studied on networks with a spanning giant component. Both, an analytical renormalization group approach and Monte Carlo simulation methods are used. In correlation clustering one considers a network interconnected with positive and negative links. The problem is to generate a clustering of the nodes, which maximizes the number of positive links within the clusters and the number of negative links between the clusters. Previous studies revealed an interesting phase-transition [1, 2, 3] for the relative size of the largest cluster (taken as order parameter) as a function of the proportion of the positive links. In the present study we consider a different order parameter which is more suitable for an analytic approach. As order parameter we define the probability of having a solution with all the nodes in the same cluster. Analytical calculations predict a similar phase transitions as the one obtained in the previous studies. Monte Carlo simulation results are in agreement with the results given by the renormalization group method.

[1] Néda Z, Florian R, Ravasz M, Libál A and Györgyi G 2006 *Physica A* 362 357

[2] Sumi R and Néda Z 2008 *Int. J. Mod. Phys. C* 19 1349.

[3] Néda Z, Sumi R, Ercsey-Ravasz M, Varga M, Molnár B and Cseh Gy 2009 *J. Phys. A: Math. Theor.* 42 345003

Session M2: Global Optimization

Monday, 11:00-13:00

Chair: Sergiy Butenko

A Deterministic Algorithm for Solving Multiobjective Optimization Problems, Yu. Evtushenko[1] and M. Posypkin[2], [1]*Dorodnicyn Computing Centre of the Russian Academy of Sciences, Moscow, Russia,* [2]*Institute for System Analysis of the Russian Academy of Sciences, Moscow, Russia*. E-mail: posypkin@isa.ru.

Optimization problems involving multiple, conflicting objectives are often approached by aggregating the objectives into a scalar function and solving the resulting single-objective optimization problem. In contrast, in this paper, we are concerned with finding a set of optimal trade-offs, the so-called Pareto-optimal set. We formally define notions of Pareto and ϵ-Pareto sets and propose a deterministic algorithm to construct finite ϵ-Pareto approximations. The algorithm is based on non-uniform space covering techniques. Its convergence to an ϵ-Pareto set is formally proved. We compare the performance of the proposed algorithm with stochastic approaches to construct Pareto-front approximations. The serial and parallel implementations of the proposed approach are also discussed.

Grid Computing Systems and Combinatorial Optimization Techniques, E. Levner, O. Shcherbina, *Institut für Mathematik, Universität Wien, Austria*. E-mail: oleg.shcherbina@univie.ac.at.

Grid computing is a form of parallel computing, whereby a network of loosely coupled computers act in concert to perform very large and complex tasks; these computers function together as a "virtual supercomputer". The tasks solved by grids need to

process large amounts of data and require a great number of computer operations. The primary advantage of grid computing is that it can produce parallel computations similar to a multiprocessor supercomputer, but at lower cost. By providing easy access to supercomputer-level processing power and knowledge resources, grids will underpin progress in European engineering, technology, business and academic research. The Grid technology enables resource sharing and dynamic allocation of computational resources, thus increasing access to distributed data, promoting operational flexibility and collaboration, and allowing service providers to scale efficiently to meet variable demand. With the emergence of grid technologies, the problem of scheduling tasks in heterogeneous systems has been arousing attention. Resource management in highly dynamic grid environments is not only about scheduling large and compute-intensive applications, but also the manner in which resources are allocated, assigned, and accessed. In most systems, submitted jobs are initially placed into a queue if there are no available resources. Therefore, there is no guarantee as to when these jobs will be executed. This causes difficult problems in time-critical or parallel applications where jobs may have interdependencies. Planning the capacity to guarantee quality of service (QoS) in such environments is a challenge because global service-level agreements (SLAs) depend on local SLAs. Due to the development of new applications and the increasing number of users with diverse needs who are exposed to Grid computing, providing users with QoS guarantees while executing applications has become a crucial problem that needs to be addressed. The advent of Grid computing and demand for QoS guarantees introduced the need for the advanced reservation (AR) mechanisms in order to coordinate resource sharing between autonomous partners. In the most general sense, this term means the guarantee of providing specific resources at a specific time. The AR in Grid computing is an important research area as it allows users to gain concurrent access to resources by allowing their applications to be executed in parallel. It also provides QoS guarantees on the availability of resources at the specified times in the future. In the proposed research project we first give the thorough analysis of reasons why the potential of AR methods and algorithms are not employed sufficiently wide in practice and then investigate the ways to increase the efficiency of the AR. We discuss combinatorial optimisation approaches to task scheduling strategies for workflow-based applications in grids using hypergraph representation, to model advanced resources reservation, taking the rationale of a grid resource manager that maximises its utility by choosing the optimal set of customers orders. This advanced reservation will be modeled via integer programming as a temporal knapsack problem (TKP), where the (hard) constraints ensure that QoS is maintained given bounded resources. In the TKP a resource allocator is given bids for portions of a time-shared resource (e.g. CPU time or communication bandwidth) or a space-shared resource (such as computer memory, disk space, or total number of beds in a hospital). Each bid specifies the amount of resource needed, the time interval throughout which it is needed, and a price offered for the resource. The resource allocator will, in general, have more demand than capacity, so it has the problem of selecting a subset of the bids that maximizes the total price or total utility obtained. The TKP is a generalization of the classic one-dimensional knapsack problem and a special case of the multi-deimensional (also known as multi-constraint) knapsack problem. We propose to apply for solving AR problems structural decomposition techniques earlier developed by Shcherbina [3,4], exact routing methods with logical constraints [1] and highly efficient approximation methods with performance guarantees earlier developed by the partner [2]. Structural decomposition algorithms compute global information using local computations (i.e., computations of information about elements of neighbourhood of variables or constraints - usually, solving subproblems)). Among structural decomposition techniques are known nonserial dynamic programming (Bertele, Brioschi) and its modifications: bucket elimination (Dechter), Seidel's invasion method; tree decomposition method (Dechter, Pearl), hypertree (Gottlob et al.) and hinge decomposition (Jeavons et al.). Some of these techniques can be used for solving IPs [3]. Temporal knapsack problem will be studied in the following way: 1) identifying a stair-case structure of TKP; 2) finding an optimal staircase structure for given TKP problem; 3) analysis of connections of TKP with interval graphs and Petrie matrices; 4) finding path decomposition for a given TKP; 5) finding efficient fully-polynomial time approximation schemes for TKP on graphs and hypergraphs.

[1] Adelson-Velsky, G.M., Levner, E. (2002) Finding extremal paths in AND-OR graphs: A generalization of Dijkstra's algorithms, Mathematics of Operations Research 27(3), 504-517

[2] Mejia-Alvarez, P., Levner, E., Mosse, D. (2004) Adaptive scheduling server for power-aware real-time tasks, ACM Transactions on Embedded Computing Systems, 3(2), 284-306.

[3] Shcherbina, O. Nonserial dynamic programming and tree decomposition in discrete optimization / In: Proceedings of Int. Conference on Operations Research "Operations Research 2006" (Karlsruhe, 6-8 September, 2006). Berlin: Springer Verlag, 2007, pp. 155-160.

[4] Shcherbina, O. (2009) Graph-based local elimination algorithms in discrete optimization. / In: Foundations of Computational Intelligence Volume 3. Global Optimization Series: Studies in Computational Intelligence, Vol. 203 / Abraham A.; Hassanien A.-E.; Siarry P.; Engelbrecht A. (Eds.). Springer Berlin / Heidelberg. 2009, XII, 528 p. P. 235-266.

D-optimal Matrices via Quadratic Integer Optimization, Ilias Kotsireas, *Wilfrid Laurier University, Canada*. E-mail: ikotsire@wlu.ca.

We show how to formulate the problem of searching for D-optimal matrices as a Quadratic Integer Optimization problem. When the sizes of the circulant matrices used to construct the D-optimal matrix are divisible by three, we describe some additional combinatorial and number-theoretic constraints. We also describe some difficult benchmark examples and some open problems. Joint work with Panos M. Pardalos.

Session T1: Optimization Methods

Tuesday, 8:30-10:30

Chair: Volodymyr Shylo

KEYNOTE **Lipschitz Global Optimization Algorithms**, Yaroslav Sergeyev, *Distinguished Professor, Dipartimento di Elettronica, Informatica e Sistemistica Universita della Calabria, Italy and Professor, N. I. Lobachevsky State University of Nizhni Novgorod, Russia*. E-mail: yaro@si.deis.unical.it.

Global optimization problems with multidimensional objective functions satisfying the Lipschitz condition over a hyperinterval with an unknown Lipschitz constant are considered. It is supposed that the objective function can be black box, multiextremal, and non-differentiable. It is also assumed that evaluation of the objective function at a point is a time-consuming operation. Different techniques based on various adaptive partition strategies are analyzed. The main attention is dedicated to diagonal algorithms, since they have a number of attractive theoretical properties and have proved to be efficient in solving applied problems. In these algorithms, the search hyperinterval is adaptively partitioned into smaller hyperintervals and the objective function is evaluated only at two vertices corresponding to the main diagonal of the generated hyperintervals. It is demonstrated that the traditional diagonal partition strategies do not fulfill the requirements of computational efficiency because of executing many redundant evaluations of the objective function. A new adaptive diagonal partition strategy that allows one to avoid such computational redundancy is described. Some powerful multidimensional global optimization algorithms based on the new strategy are introduced. Results of extensive numerical experiments performed to test the methods proposed demonstrate their advantages with respect to diagonal algorithms in terms of both number of trials of the objective function and qualitative analysis of the search domain, which is characterized by the number of generated hyperintervals.

Variable Objective Search, Oleksandra Yezerska[a], Sergiy Butenko[a], and Balabhaskar Balasundaram[b], [a]*Texas A&M University, College Station, TX 77843-3131, USA*, [b]*Oklahoma State University, Stillwater, OK 74078, USA*. E-mail: yaleksa@tamu.edu

This paper introduces the variable objective search framework for combinatorial optimization. The method utilizes different objective functions used in alternative mathematical programming formulations of the same combinatorial optimization problem in an attempt to improve the solutions obtained using each of these formulations individually. The proposed technique is illustrated using alternative quadratic unconstrained binary formulations of the classical maximum independent set problem in graphs.

Necessary and sufficient conditions in the problem of optimal consumption from investment in incomplete markets, Oleksii Mostovyi, *Carnegie Mellon University, Pittsburgh, PA, USA*. E-mail: omostovy@andrew.cmu.edu.

We consider the problem of maximizing expected utility from consumption in a constrained incomplete semimartingale market, and establish a general existence and uniqueness result using techniques from convex duality. The goal is to find a minimal condition on a model and a utility function for the validity of several key assertions of the theory to hold true. We show that a necessary and sufficient condition on the utility function and the model is that the value function of the dual problem is finite. Also, we discuss the future work, i.e. the extension of the current result on a more general model.

Session T2: Networks Everywhere

Tuesday, 11:00-13:00

Chair: Oleksandra Yezerska

A Keller's conjecture and investigation of keller7 graph, Volodymyr Shylo[1], Vasyliy Ogar[2], Ivan Gradinar[3] and Dmytro Boyarchuk[1], [1]*V.M. Glushkov Institute of Cybernetics, Kyiv, Ukraine*, [2]*IBRAE of the Russian Academy of Sciences, Moscow, Russia,* [3]*Uzhgorod National University, Uzhgorod, Ukraine.* E-mail: v.shylo@gmail.com

Keller's conjecture in n dimensions states that every tiling of $\mathbb{R}^n$ by unit cubes contains two cubes that meet in a $n-1$ dimensional face. The Keller's conjecture has been proven true for $n \leq 6$, but disproved for $n \geq 8$ [1], leaving only one dimension ($n = 7$) as the unresolved case [2]. Corrádi and Szabó [3] reduced Keller's conjecture into the problem of finding maximum cliques. In this talk we consider the maximum clique problem in the graph keller7. We modified algorithm from [4], which was earlier utilized to obtain new sizes of the maximal independent sets in graphs arising from coding theory. In this talk we present the results of our computational experiments.

[1] Mackey, J., A Cube Tiling of Dimension Eight with No Facesharing. Disc. Comput. Geom. 28, pp. 275–279 (2002).

[2] Shor, P., Minkowski's and Keller's Cube-Tiling Conjectures. http://www-math.mit.edu /∼shor/lecture_notes.ps

[3] Corrádi K. and Szabó S., A combinatorial approach for Keller's conjecture. Period. Math. Hungar.21, pp. 91–100 (1990).

[4] Sergienko I.V., Shylo V.P., Discrete optimization problems: Issues, solution methods, investigations. Kiev: Naukova Dumka, 2003 (in Russian).

A distributed 4-approximation algorithm for the k-bottleneck connected dominating set problem, Anurag Verma and Sergiy Butenko, *Industrial and System Engineering, Texas A&M University, College Station, TX, USA*. E-mail: anuragverma@tamu.edu.

Wireless sensor networks require a virtual backbone for efficient communication within the sensors. Connected dominating sets (CDS) have been studied as a method of choosing nodes to be in the backbone. However, a CDS might lead to unbalanced energy requirement which might cause some nodes in the backbone to die out much earlier than the others, effectively destroying the whole backbone. k-Bottleneck Connected Dominating Set (k-BCDS) was introduced recently as an alternative strategy that minimizes the maximum distance any node in the backbone has to transmit, thus balancing the energy requirement of all nodes. This paper provides a 4- approximate distributed algorithm for the k-BCDS problem.

An algorithm for the solution of a clustering problem with fuzzy distances using binary integer programming, Julio Rojas-Mora and Jaime Gil-Lafuente, *Department of Business Economics and Organization, University of Barcelona, Barcelona, Spain*. E-mail: jrojasmo7@alumnes.ub.edu.

In many environments, it is necessary to group items according to their similarity, constrained to the a certain number of groups. However, it is possible that the only information available on the characteristics of these elements is subjective and uncertain, making the definition of this similarity a confusing and biased process. Tools provided by the theory of fuzzy subsets allow the collection of this information, which can then be compared with a fuzzy distance function that models the separation between any given pair of elements. Nonetheless, these distances do not correspond to real numbers, but to uncertain values that take the form of trapezoidal fuzzy numbers, preventing the application of traditional clustering techniques. This paper proposes an algorithm that iteratively solves binary integer programming models (BIP), obtaining the clusters that minimize their aggregate distance relative to a given threshold called α-cut, which represents the similarity level of the elements in the clusters. For each α-cut used in the algorithm we will have a set of clusters, with more clusters in higher α-cuts and bigger clusters in lower α-cuts. The solution to the problem is given by the biggest α-cut for which the required number of clusters is found.

Probabilty Generating Function Techniques for Network Optimization Problems under Uncertainty with CVaR Constraints, Alex Savenkov, Vladimir Boginski, and M. Yang, *University of Florida, Gainesville, FL, USA*. E-mail: savenkov@stat.ufl.edu.

Optimization models arising in connectivity and flow problems in complex networks are often associated with uncertain network component disruptions that may affect the structure of the corresponding optimal solutions. Quantitative risk measures can be incorporated into mathematical programming formulations in order to take into account the effects of these uncertain disruptions and minimize or restrict the potential collateral losses. In the recent research, Conditional Value-at-Risk was first utilized as a risk measure that can be effectively incorporated into several classes of network optimization problems. However, the resulting problems are often computationally challenging due to the increased number of variables and constraints related to the generated random samples (scenarios) that are used to approximate CVaR. In this work, we attempt to address these issues by using probability generating function techniques to calculate the CVaR for the loss functions arising in the considered optimization problems. The proposed techniques can potentially reduce the size of the problems and allow one to find robust solutions for large network instances in a reasonable time.

Session W1: Transportation and Logistics

Wednesday, 08:30-10:30
Chair: Zeynep Ertem

KEYNOTE **Local search for the hop-constrained directed Steiner tree problem with application to UAV-based multi-target surveillance**, Oleg Burdakov, *Department of Mathematics, Linköping University, Sweden*. E-mail: olbur@mai.liu.se.

Given a weighted directed graph with a selected root node and a set of terminal nodes, the directed Steiner tree problem (DSTP) is to find a directed tree of the minimal weight which is rooted in the root node and spanning all terminal nodes. We consider the DSTP with a constraint on the total number of arcs (hops) in the tree. This problem is known to be NP-hard, and therefore, only heuristics can be applied in the case of its large-scale instances. For the hop-constrained DSTP, we propose local search strategies aimed at improving any heuristically produced initial Steiner tree. They are based on solving a sequence of hop-constrained shortest path problems for which we have recently developed efficient label correcting algorithms. The approach presented in this talk is applied to solving the problem of placing unmanned aerial vehicles (UAVs) used for multi-target surveillance. The efficiency of our algorithms is illustrated by results of numerical experiments related to this applied problem.

A Bi-objective Model for Recollecting Residuals in Rural Areas: A Tabu Search and MOAMP based Method, Jose Rubén Gómez[a] and Joaquín Pacheco[b], [a]*Department of Graphical Expression, University of Burgos*, [b]*Department of Applied Economy, University of Burgos*. E-mail: jrgomez@ubu.es, jpacheco@ubu.es.

In this work a bi-objective model for recollecting bins of Solid Urban Residuals in rural areas in a temporal horizon is presented. The objectives involved are: reducing costs of transport and improving level service. Specifically the level service depends very directly on the frequency of pick-up at the different points. An algorithm ad-hoc to this model is proposed to obtain the set of no dominated solutions. This algorithm is based on the MOAMP strategy. It has show to be able to find, to obtain dense and large sets of not-dominated, even in small instances, Also it shows to perform better than an adaptation of the very-well known algorithm NSGA-II for Multi-objective Problems.

On the transportation subproblem of Euro-2012, Vasyl Gorbachuk, *Cybernetics Institute, National Academy of Sciences of Ukraine, Kyiv, Ukraine*. E-mail: GorbachukVasyl@netscape.net.

The final rounds of European football championship of 2012 (Euro-2012) will take place in 8 cities of Poland (Gdansk, Poznan, Warsaw, Wroclaw) and Ukraine (Donetsk, Kharkiv, Kyiv, Lviv). Due to the underdeveloped infrastructure, there are some transportation problems. For instance, today a car or train trip from Gdansk to Donetsk may take days. Consider the subroute Warsaw (City 1) – Kyiv (City 2) – Donetsk (City 3). Denote P_{ij}^k the price per passenger for travel from City i to City j by transportation $k \in \{c, t, a\}$, $i, j \in \{1, 2, 3\}$, $i \neq j$, where c, t, a stands for car, train, airplane transportation, respectively. These kinds of transportation may be disaggregated further, including bus, taxi, individual car, regular flight, charter etc. If X_{ij}^k is a number of passengers willing to pay P_{ij}^k for the corresponding travel, let

$$P_{ij}^k = a_{ij}^k - b_{ij}^k X_{ij}^k, \tag{1}$$

where a_{ij}^k, b_{ij}^k are some positive demand parameters. Besides, each travel takes time

$$t_{ij}^k = T_{ij}^k + u_{ij}^k X_{ij}^k, \tag{2}$$

where T_{ij}^k, u_{ij}^k are some positive congestion parameters. Denote v monetary value of time unit for a representative passenger.

Assume P^t_{ij} is regulated. On the subroute 1–2–3 a rational representative passenger minimizes her expenditures

$$\min\{P^k_{12} - v\,t^k_{12} + P^l_{23} - v\,t^l_{23};\ P^a_{13} - v\,t^a_{13}\}, \qquad (3)$$

$k,\ l \in \{c,\ t,\ a\}$, choosing X^m_{12} and X^n_{23}, where $n \in \{c,\ a\}$, under a given price P^t_{ij} of train transportation, under the constraints (1), (2) and the capacity constraints

$$X^k_{ij} \le U^k_{ij}, k \in \{c,\ t,\ a\}, i,\ j \in \{1,\ 2,\ 3\}, i \ne j. \qquad (4)$$

Then the regulator, knowing $X^m_{12}(P^t_{12})$ and $X^n_{23}(P^t_{23})$, $m,\ n\ \in \{c,\ a\}$, chooses P^t_{12} and P^t_{23} to maximize its total operational profit

$$\max\{(P^k_{12} - c^k_{12})X^k_{12} + (P^l_{23} - c^l_{23})X^l_{23};\ (P^a_{13} - c^a_{13})X^a_{13}\} \qquad (5)$$

under the capacity constraints (4), where c^k_{ij} is the cost per passenger of corresponding transportation. The expected profits imply appropriate investments. As the subproblem (1)–(5) accounts for only 3 of 8 attainable cities, the general transportation problem of Euro-2012 needs developed techniques of network and multi-level optimization [1].

[1] S. Butenko, J. Gil-Lapuenete, P. M. Pardalos (Eds.). *Economics, management and optimization in sports*, Springer, 2004.

Session W2: Networks Everywhere Again

Wednesday, 11:00-13:00

Chair: Anurag Verma

Network techniques in fMRI brain data analysis, Dmytro Korenkevych, Frank Skidmore, and Panos Pardalos, *University of Florida, Gainesville, FL, USA*. E-mail: dmitriy@ufl.edu.

Convergent studies have suggested that graph metrics may be useful to characterize resting functional Magnetic Resonance Imaging and the resting Magnetoencephalogram. These studies suggest that the brain can be usefully conceptualized as a "Small World Network" designed to ideally transmit parallel information at relatively low cost. Disease states, drugs, or aging would be predicted to degrade the economical properties of the network and result in measurable alterations in network efficiency. Recent studies have supported this idea, showing that aging, psychiatric and neurologic diseases, and dopaminergic blockade all result in altered network efficiency. We investigated the efficiency and cost of human brain funcional networks as measured by fMRI in individuals with idiopathic Parkinson's disease (N=14) compared to healthy age-matched controls (N=15). Functional connectivity between 116 cortical and subcortical regions was estimated by wavelet correlation analysis in the frequency interval of 0.01 Hz to 0.10 Hz. Efficiency and cost of the associated network was analyzed, comparing PD to healthy controls. We found that individuals with Parkinson's disease had a marked decrease in local and global efficiency compared to healthy age-matched controls. Our results suggest that algorithmic approach and graph metrics might be used to identify and track neurodegenerative diseases, however more studies will be needed to evaluate sensitivity and specificity of this type of analysis to different disease states.

Network-based models for analysis of SNPs, Zeynep Ertem, Sergiy Butenko, and Clare Gill, *Texas A&M University, College Station, TX, USA*. E-mail: zeynepsertem@gmail.com.

A great number of challenges arise from rapid advances that are occur- ring in genomic research. Massive data sets are generated from DNA related studies and analyzing those in terms of operations research and optimization techniques comes into prominence. Constructing associated graph-theoretic models becomes more important as communicating vast amount of information accumulated in the laboratories each day is getting harder. Single Nucleotide Polymorphisms (SNPs) are of paramount importance in DNA related studies due to their role in variation of species. In this talk, we first survey network-based models arising in computational biology and then concentrate on applications of cluster-detection algorithms to analysis of SNP data.

Graph-theoretic analysis of local search-based techniques in combinatorial optimization, Alla R. Kammerdiner and Eduardo L. Pasiliao, *Air Force Research Laboratory, Eglin Air Force Base, Florida 32542-5000*. E-mail: alla.ua@gmail.com.

We consider a directed graph induced by application of local search procedures for solving combinatorial optimization problems. The structure of the solution space is investigated by building on recent theoretical results concerning the Laplacian of directed graphs. We focus our attention on a class of multidimensional assignment problems. Numerical simulation results are provided to demonstrate the applicability of our approach.

On Greedy Approximation Algorithms for a Class of Stochastic Assignment Problems, Serdar Karademir[a], Oleg Prokopyev[a], and Nan Kong[b], [a]*Industrial Engineering, University of Pittsburgh, Pittsburgh, PA, USA,* [b] *Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN, USA*. E-mail: sek73@pitt.edu.

In this talk we consider a two-stage stochastic extension of the classical linear assignment problem. For each agent and job, the decision maker has to decide whether to make assignments now or to wait for the second-stage. Assignments of agents and jobs for which decisions are delayed to the second-stage are then completed based on the scenario realizations. We summarize two greedy approximation algorithms from the literature and describe a set of necessary optimality conditions that generalizes the key ideas behind each of the two algorithms. Based on these necessary optimality conditions, we propose a more advanced approximation algorithm and provide the results of our computational experiments.