האגודה הישראלית לחקר ביצועים

(איל"ב)

הכינוס השנתי 2014

22 – 23 באפריל

אוניברסיטת תל אביב
הפקולטה לניהול ע"ש ליאון רקנאטי

בתמיכת:

הוועדה המארגנת:

ערן חנני (יו"ר)
שושנה אנילי
ניב בוכבינדר
מיכל צור

הכנס השנתי של האגודה הישראלית לחקר ביצועים

אוניברסיטת תל אביב, הפקולטה לניהול ע"ש ליאון רקנאטי, תל אביב, 23 - 22 באפריל 2014

Tuesday			Wednesday		
09:00-09:30	*Registration*	401,402	09:00-09:30	*Registration*	401,402
09:30-09:40	**Opening Session**	ליאון	09:30-10:45	**Parallel Sessions W1**	
09:40-10:35	**Naor Plenary Lecture** **Avishai Mandelbaum**	ליאון		Transportation 2 Approximation Schemes Queueing 2 Operations Games Scheduling 2	250 251 301 302 408
10:35-10:55	*Break*	401,402	10:45-11:05	*Break*	401,402
10:55-12:10	**Parallel Sessions T1**		11:05-11:20	**Prize Award Ceremony**	ליאון
	Transportation 1 Operations Management 1 Simulation Health Care Applications Game Theory 1	301 302 304 305 306	11:20-12:15	**Plenary Lecture** **Retsef Levi**	ליאון
12:10-13:35	*Lunch* *& ORSIS General Assembly* (13:20)	גן הדקלים	12:15-13:40	*Lunch*	גן הדקלים
13:35-14:30	**Plenary Lecture** **Refael Hassin**	ליאון	13:40-14:30	**Plenary Lecture** **Oren Kurland**	ליאון
14:30-15:15	**Semi-Plenary Tutorial S1**		14:30-15:15	**Semi-Plenary Tutorial S2**	
	Isaac Meilijson Jacob Zahavi	405 304		Eilon Solan Seffi Naor	302 305
15:15-15:35	*Break*	401,402	15:15-15:35	*Break*	401,402
15:35-17:15	**Parallel Sessions T2**		15:35-17:15	**Parallel Sessions W2**	
	Scheduling 1 Queueing 1 Stochastic Models Optimization 1 Continuous Optimization	301 302 304 305 306		Game Theory 2 Strategic Behavior in Queues Stochastic Optimization Optimization 2 Operations Management 2	250 254 301 302 305
17:20-22:00	**Evening Program** (bus leaves at 17:20) 18:00 Guided walking tour along Rothschild Boulevard – Yona Wiseman. Starting Point: Rothschild @ Hertzel 20:00 Dinner at Derby Bar restaurant (on 96, Yigal Alon st.)				

מיקום: אולם ליאון נמצא בקומת הכניסה (קומה 1). בשאר החדרים, הספרה הראשונה מציינת את מספר הקומה. מעליות נמצאות בקומת הכניסה בצידה הדרומי. ארוחות הצהריים תוגשנה בגן הדקלים הנמצא בחזית בניין קפלון ובסמוך לבית הכנסת.

תחבורה: דרך ההגעה המומלצת לת"א היא ברכבת. יש לשים לב שתחנת האוניברסיטה ממוקמת במרחק הליכה של כ- 15 דקות ממקום הכנס, אך מרבית ההליכה היא בעלייה די תלולה, כולל מדרגות. לכן, מי שרוצה להימנע מכך, יכול לרדת בתחנות האוניברסיטה או ת"א-מרכז ולקחת אוטובוס (יש מספר קווים בתדירות גבוהה) המגיע לשער הראשי של האוניברסיטה (שער 7) ברחוב חיים לבנון, סמוך מאוד לבניין רקנאטי. לשוהים במלון תהיה אפשרות לאחסן תיקים בבניין רקנאטי (ומשם בערב על אוטובוס הסיור).

חניה: חניונים סמוך לשערים 4,8. ביום שלישי תהיה כנראה אפשרות לחנות לאורך רחובות לבנון ואיינשטיין (מפה מצורפת בסוף).

Detailed Program - Tuesday, 22.4

09:00-09:30	*Registration*	401,402

09:30-09:40 **Opening Session** **ליאון**

09:40-10:35 **Naor Plenary Lecture** **ליאון**

Speaker: ***Avishai Mandelbaum, Technion***

Chair and opener: ***Aharon Ben-Tal, Technion***

10:35-10:55	*Break*	401,402

10:55-12:10 **Parallel Sessions T1**

Transportation 1 Chair: Hillel Bar-gera **301**	Michal Nitzani, Hillel Bar-Gera	Computational Stability of Macroscopic Dynamic Traffic Assignment with Traffic Signals
	Avi Herbon, Yuval Hadas	Generalized Newsvendor Model for Determining Public-Transit Route's Optimal Frequency and Vehicle Capacity
	Lauren M. Gardner, Stephen D. Boyles, Hillel Bar-Gera, Kelly Tang	Robust Tolling Schemes for High-Occupancy/Toll (HOT) Facilities Under Variable Demand
Operations Management 1 Chair: Yigal Gerchak **302**	Tal Avinadav, Avi Herbon, Uriel Spiegel	Optimal ordering and pricing policy for demand functions that are separable into price and inventory age
	Tal Avinadav, Tatyana Chernonog, Yael Perlman	Analysis of Protection and Pricing Strategies for Digital Products under Uncertain Demand
	Yossi Hadad, Baruch Keren	An economic partition of a given number of machines among operators
Simulation Chair: Itzhak Benenson **304**	Gennady Waizman, Shraga Shoval, Itzhak Benenson	Micro-Simulation of the Car-Pedestrian Road Accidents
	Tamir Balasha, Tomer Toledo	Simulation-based Optimization of Actuated Traffic Signal Plans
	Nadav Levy, Itzhak Benenson	Modeling car parking in the city – What is easy and what is complicated?
Health Care Applications Chair: Joseph Pliskin **305**	Guy Wachtel, Amir Elaluf, Eugene Levner	An alternative scheduling approach for improving the emergency department performance
	Carri W. Chan, Galit Yom-Tov	Managing Healthcare Systems: Speedup versus Admission Control
	Dan Yamin, Arieh Gavious, Eyal Solnik, Nadav Davidovitch, Ran D. Balicer, Joseph S. Pliskin	An Innovative Influenza Vaccination Policy: Targeting Last Season's Patients
Game Theory 1 Chair: Ella Segev **306**	Shiran Rachmilevitch	The Nash solution is more utilitarian than egalitarian
	Igal Milchtaich	Polyequilibrium
	Yizhaq Minchuk, Aner Sela	All-pay auctions with multiple prizes under complete and incomplete information

12:10-13:35	*Lunch & ORSIS General Assembly* (13:20)	גן הדקלים

13:35-14:30 **Plenary Lecture** **ליאון**

Speaker: ***Refael Hassin, Tel Aviv University***

Chair and opener: ***Shoshana Anily, Tel Aviv University***

14:30-15:15 **Semi-Plenary Tutorial S1**

Speaker: ***Isaac Meilijson, Tel Aviv University*** **405**

Speaker: ***Jacob Zahavi, Tel Aviv University*** **304**

15:15-15:35	*Break*	401,402

15:35-17:15 **Parallel Sessions T2**

Scheduling 1 Chair: Michal Penn **301**	Chen Kaminer, Hussein Naseraldin, Liron Yedidsion	The Common Due-Date Assignment Problem in Scheduling: A Robust Optimization Approach
	Tal Shusterman	Weighted Throughput in a single machine preemptive scheduling with continuous controllable processing times
	Dvir Shabtay, Omri Dover, Moshe Kaspi	Single Machine Two-Agent Scheduling Involving a Just-In-Time Scheduling Criterion
	Dvir Shabtay, Kfir Arviv, Helman Stern, Yael Edan	A Combined Robot Selection and Scheduling Problem for Flow-Shops with No-Wait Restrictions
Queueing 1 Chair: Gad Rabinowitz **302**	Ruth Shilman, Dean Grosbard, Gadi Rabinowitz, Israel Tirkel	Queueing Networks Model for Manufacturing Systems with Various Policies of Downtimes
	Dean Grosbard, Adar Kalir	Queueing Network Decomposition in the Analysis of Fab Performance
	Shai Goren, Gad Rabinowitz, Yoav Kerner	Multi-cell inspection and repair resources allocation
	Itai Gurvich, Junfei Huang, Avishai Mandelbaum	Excursion-based universal approximations for the Erlang-A queue in steady-state
Stochastic Models Chair: David Perry **304**	Yonit Barron	An (s,k,S) Fluid Inventory Model with exponential lead time and order cancellations
	Esther Frostig	The moments of the discounted loss and the discounted dividends for a spectrally negative risk process
	Onno Boxma, David Perry	A useful Pollaczek-Khinchine type equation with applications to closed stochastic storage systems in operations research
Optimization 1 Chair: Hagai Ilani **305**	Shimrit Shtern, Aharon Ben-Tal	A Semi-Definite Programming Approach for Robust Tracking
	Baruch Mor, Gur Mosheiov	Single machine batch scheduling with two competing agents to minimize total flowtime
	David Raz, Ariel Daliot	A Practical Approach for Large Scale Optimal Pump Scheduling with Operational Constraints
	Hagai Ilani, Elad Shufan, Tal Grinshpoun	A (non-trivial) two-destination transportation problem
Continuous Optimization Chair: Amir Beck **306**	Ron Shefi, Marc Teboulle	A Dual Method for Minimizing a Nonsmooth Objective over One Smooth Inequality Constraint
	Amir Beck, Yakov Vaisbourd	Optimization Methods for Solving the Sparse PCA Problem
	Yoel Drori, Shoham Sabach, Marc Teboulle	An $O(1/\varepsilon)$ Algorithm for a Class of Nonsmooth Convex-Concave Saddle-Point Problems
	Amir Beck, Nadav Hallak	On the Minimization Over Sparse Symmetric Sets

17:20-22:00	**Evening Program (bus leaves at 17:20)** **18:00 Guided walking tour along Rothschild Boulevard – Yona Wiseman** **20:00 Dinner at Derby Bar restaurant (on Yigal Alon st.)** **Transportation will be provided at the end of the evening to the University, Leonardo Hotel, and Tel-Aviv Central train station.**

Detailed Program - Wednesday, 23.4

09:00-09:30	*Registration*	401,402

09:30-10:45 Parallel Sessions W1

Transportation 2 Chair: Tal Raviv **250**	Nicole Adler, Alfred Shalom Hakkert, Tal Raviv, Mali Sher	The traffic police location and schedule assignment problem
	Inbal Haas, Shlomo Bekhor	An optimization model that accounts for interdependencies between groups of infrastructure related projects
	Nicole Adler, Xiaowen Fu, Tae H. Oum, Chunyan Yu	Air Transport Liberalization and Airport Slot Allocation: The case of the Northeast Asian Transport Market
Approximation Schemes Chair: Danny Segev **251**	Nir Halman	Approximation Schemes for Sample-Based Non-linear Newsvendor
	Retsef Levi, Thomas Magnanti, Yaron Shaposhnik	Scheduling with Testing
	Danny Segev	An Approximate Dynamic-Programming Approach to the Joint Replenishment Problem
Queueing 2 Chair: Moshe Haviv **301**	Efrat Perel, Uri Yechiali	Non-Preemptive Two-Queue Polling System with Threshold-Based Switching Policy
	Nir Perel, Uri Yechiali	The Israeli Queue with Retrials
	Sophie Hautphenne, Moshe Haviv	Bias-optimization in queueing models
Operations Games Chair: Shoshana Anily **302**	Roi Feldhaim, Liron Yedidsion, Gal Zahavi	Utilizing Risk Allocation for Revenue Management
	Dana Sherill-Rofe, Tatiana Chernonog	Hospital – Sick Fund Contracting and Quality of Care: A Game Theoretical Approach
	Shoshana Anily	Cooperation in service systems: The 3-D assignment M/G/c/c game
Scheduling 2 Chair: Gur Mosheiov **408**	Enrique Gerstl, Gur Mosheiov	Single Machine Just-in-Time Scheduling Problems with Two Competing Agents
	Tal Grinshpoun, Elad Shufan, Hagai Ilani	Generalization of the rank matrix representation for shop problems
	Enrique Gerstl, Gur Mosheiov	A two-stage flexible flow shop problem with unit-execution-time jobs and batching

10:45-11:05	*Break*	401,402

11:05-11:20 Prize Award Ceremony ליאון

11:20-12:15 Plenary Lecture ליאון

Speaker: ***Retsef Levi, Massachusetts Institute of Technology***

Chair and opener: ***Niv Buchbinder, Tel Aviv University***

12:15-13:40	*Lunch*	גן הדקלים

13:40-14:30 Plenary Lecture ליאון

Speaker: ***Oren Kurland, Technion***

Chair and opener: ***Moshe Haviv, Hebrew University of Jerusalem***

14:30-15:15 Semi-Plenary Tutorial S2

Speaker: ***Eilon Solan, Tel Aviv University*** **302**

Speaker: ***Seffi Naor, Technion*** **305**

15:15-15:35	*Break*	401,402

15:35-17:15 **Parallel Sessions W2**

Game Theory 2 Chair: Ella Segev **250**	Yaron Azrieli, Eran Shmaya	Rental Harmony With Roommates
	Sergio O. Parreiras, Anna Rubinchik	Segregation by ability increases competitiveness in contests
	Irit Nowik, Shmuel Zamir	The game on the risk of deviating from the Nash strategy
	Gabrielle Gayer, Ella Segev	Revealing private information in Bargaining
Strategic Behavior in Queues Chair: Yoav Kerner **254**	Moshe Haviv, Binyamin Oz, Martin L. Puterman	Centralized Planning of Relative Priorities in Parallel Network of Queues
	Refael Hassin, Alexandra Koshman-Kaz	Optimal control of a queue with high-low delay announcements
	Nahum Shimkin, Eitan Altman	A Game of Ad Submission Timing Over a Shared Display Board
	Yoav Kerner, Eliran Schertzer	Strategic reneging from an M/G/1 queue
Stochastic Optimization Chair: Israel David **301**	Michael Bendersky, Israel David	Advanced Methods for Artillery Fire Transfer
	Adam Shwartz, Segev Wasserkrug, Alexander Zadorojniy, Sergey Zeltyn	Decomposition Algorithms for Constrained Markov Decision Process with an Application to Wastewater Treatment Plants' Optimization
	Asaf Levin, Aleksander Vainer	Adaptivity in the stochastic blackjack knapsack problem
	Michael Bendersky, Israel David	The Full-Information Secretary Problem – New Explicit Results
Optimization 2 Chair: Noam Goldberg **302**	Hussein Naseraldin, Opher Baron	Robust Capacity Planning Under Service Constraints
	Amnon Gonen, Uriel Israeli, Tzahi Avrahami	An Improved Heuristic Algorithm for the Set Covering
	Segev Wasserkrug, Alexander Zadorojniy, Alexey Tsitkin	Relieving Pressure: Optimizing Water Distribution Pressure Management at Valley of the Moon Water District
	Noam Goldberg, Sven Leyffer	Active Set Method for Second-Order Conic-Constrained Quadratic Programming
Operations Management 2 Chair: Dina Smirnov **305**	Simona Cohen-Kadosh, Zilla Sinuany-Stern	The Effect of the Socio-Economic Index on the Efficiency of Orthopedic Wards via Data Envelopment Analysis
	Moshe Kaspi, Moshe Zofi, Ron Teller	Maximizing the Profit per Unit Time for the Travelling Salesman Problem
	Eran Hanany, Shulamit Lederman, Michal Tzur	Strategic Lateral Transshipment with Communication Constraints
	Dina Smirnov, Yale T. Herer	The Two-Phase Distribution Problem

Plenary Lectures

Naor Plenary Lecture

Chair and opener: ***Aharon Ben-Tal, Technion***

Speaker: ***Avishai Mandelbaum, Technion***

Data-Based Service-Networks: A Framework for (Asymptotic) Inference, Design and Control of Service Systems, in Real-Time

or (a "buzzworded" title)

Instant-Modeling and e-Analysis of Service Networks: From Small Measurements through Big-Data + Analytics to Workflows & Wiki-OR

The lecture is on Service Systems, pertaining to hospitals, telephone call centers, internet sites, bank branches and more. The focus is on operational performance, for example accessibility, delay and utilization levels. (But operational characteristics also serve as surrogates for other performance measures, for example financial, psychological and clinical.) The scientific goal is the creation of principles and tools that support system engineering and management. And the means for achieving this goal is the marriage of theory with data.

To be more concrete, I am modeling complex service systems as relatively simple processing networks. My theoretical framework is asymptotic queueing theory, specifically parsimonious fluid models and their diffusion refinements: queueing theory is ideally suitable for capturing the operational tradeoff that is at the core of any service, namely quality vs. efficiency (possibly augmented with fairness or profitability); and asymptotic analysis accommodates complex service characteristics that are otherwise intractable, for example transience, scale and scope (mass customization). My empirical framework builds on an extensive data repository of service event-logs, at the level of the individual customer-server transaction. Marrying the two frameworks, theoretical and empirical, will enable the creation of models directly from data, and consequently the validation of their value against actual service systems. (This is in contrast to prevalent OR/IE/OM practice, where models are typically remote from data, and asymptotic approximations are validated for merely accuracy against their originating mathematical models.)

The ultimate goal is a platform for creating data-based models in real-time – simulation, empirical and mathematical. The creation of such a platform calls for contributions from several sub-disciplines of OR, and beyond. This platform will be accessible to researchers, students and practitioners. Its prerequisites include inference of model primitives, structure and protocols: all this is pursued at the Technion SEE Laboratory (SEE = Service Enterprise Engineering).

Plenary Lecture

Chair and opener: ***Shoshana Anily, Tel Aviv University***

Speaker: ***Refael Hassin, Tel Aviv University***

Rational queueing

"Rational queueing" refers to models of queueing systems with multiple decision makers aiming to optimize (in most cases) contradicting objectives. The research in this area characterizes the equilibrium outcomes of the resulting non-cooperative games. A book by Hassin and Haviv (2003) presented the topic and surveyed the state of the art at that time. Since then, the area has been developing in an accelerated pace, and the talk will mention an on-going project that surveys

about 600 papers that are not included in the book, almost all of them were published after 2003. The talk will mention central contributions in this area, with the emphasis on interesting qualitative insights that are unique to queueing systems.

Plenary Lecture

Chair and opener: ***Niv Buchbinder, Tel Aviv University***

Speaker: ***Retsef Levi, Massachusetts Institute of Technology***

Optimal and Near-Optimal Algorithms for the Assortment Planning Problems

Assortment planning is a major operational issue that arises in many industries, such as retailing, airlines and consumer electronics. Given a set of products (or services) that are differentiated by price, quality and possibly other attributes, one has to decide on the subset of products and the respective quantities that will be stocked and offered to customers who usually exhibit substitution behavior.
We study several assortment models with and without dynamic substitution and show how different assumptions on the underlying customer choice model translate to the complexity of the model. We also discuss several important cases that admit efficient optimal algorithms, as well as cases where there exists polynomial time approximation scheme (PTAS). Interestingly, some of the near optimal solutions are based on sparse assortments.

Plenary Lecture

Chair and opener: ***Moshe Haviv, Hebrew University of Jerusalem***

Speaker: ***Oren Kurland, Technion***

Using the cluster hypothesis to improve search engine effectiveness

The fundamental ad hoc retrieval task, addressed by search engines, is ranking documents in a corpus by their presumed relevance to a query. The cluster hypothesis for ad hoc retrieval implies that similar documents should be relevant to the same queries. The hypothesis has given rise to a large body of work on using clusters of similar documents for retrieval. We present a novel approach to ranking document clusters which is based on using Markov Random Fields.
Empirical evaluation demonstrates the merits of the approach. Specifically, a search engine based on the suggested approach won the first place (according to most evaluation criteria) in the annual search engine competition organized by the national institute of standards and technology (NIST).

Semi-Plenary Tutorials

S1

Isaac Meilijson*, *Tel Aviv University

LIFO and LIFE - Inventory management of secretory cells

The talk will survey joint work with Ilan Hammel (Faculty of Medicine at TAU) and students on modeling the granules that secrete mediators from the cell to its environment. These granules, that grow by homotypic fusion with a recently packaged (unit) granule, are at some stage secreted from the cell by heterotypic fusion with its membrane. Thus, the lifetime of a granule in the cell follows a Jackson network consisting of M/M/infinity queues in tandem with possible exit at every stage. The rates of growth and exit, that depend on particle interaction of some (SNARE) proteins responsible for both types of fusion, dictate nearly-LIFO inventory management.
Why does the cell store such inventory of hundreds or thousands of granules? Besides basal secretion as described above, the cell (acting as an inventory buffer) is requested at times to provide evoked bursts of granules. The information content of the secretion dichotomy (basal-evoked), to be described in terms of statistical detection of a change-point-in-distribution, may force the buffer to be quite large.

Jacob Zahavi*, *Tel Aviv University

Tutorial on Predictive Analytics

Today's era of Big Data created an increasing interest in mining the massive amounts of data being collected these days by most organizations to extract useful knowledge from the data for decision making. Predictive analytics is the workhorse of data mining. It is concerned with predicting future events that one can acts upon, for example the probability of responding to a marketing offer, the likelihood of churning, default probabilities, and many others. Predictive analytics is an interdisciplinary field lying in the intersection of, among others, statistics, machine learning, artificial intelligence, visualization and high speed computation. The high dimension of the data involved, makes the process of building predictive models very complex.
In this tutorial, we will review the basic modeling approaches in predictive analytics and discuss some of the practical implications of applying predictive analytics in practice.

S2

Eilon Solan*, *Tel Aviv University

Title: Stopping games - a survey

In the past decade many results have been proven with regards to stopping games, both in discrete and continuous time. I will survey these results and explain the difference in nature that leads to different results in the two setups.

Seffi Naor*, *Technion

Recent Progress in Maximization of Submodular Functions

The study of combinatorial problems with submodular objective functions has attracted much attention recently, and is motivated by the principle of economy of scale, prevalent in real world applications. In particular, submodular functions are commonly used as utility functions in economics and algorithmic game theory. Submodularity and submodular maximization play a major role in combinatorial optimization, where several well known examples of submodular functions in this setting include cuts in graphs and hypergraphs, rank functions of matroids, and covering functions.
I will discuss several recent results on maximizing submodular functions, both monotone and non-monotone.

Book of abstracts (grouped by sessions)

Tuesday, 22.4

T1

Transportation 1 - Chair: Hillel Bar-gera

Michal Nitzani, Hillel Bar-Gera

Computational Stability of Macroscopic Dynamic Traffic Assignment with Traffic Signals

This research explores a continuous-flow analytic dynamic traffic assignment (DTA) model developed to consider isolated uncoordinated traffic signals. The dynamic network loading (DNL) component relies on trajectories and anticipated arrival order to nodes in order to achieve consistency between flow propagation along routes and single link traffic behavior. The traffic signal component consists of: a non-stationary cycle-to-cycle Markov chain for the evaluation of queue length randomness; deterministic delay consideration; within cycle behavior treatment; and a scheme for integration with the network level model.
A primary focus of this research is the issue of solution stability and its relationship to model specification and discretization. An interesting connection between DTA models and general finite element models in this respect is presented, particularly regarding lag options in the discrete form of the equilibrium condition. The DTA problem is formulated in a novel way that illustrates the similarity between DTA discretization challenges and general finite element models. Our results regarding these lag options, known as "forward" vs. "backward" Euler method, or as "reactive" vs. "predictive" user-equilibrium, confirm previous findings and show that solution stability and spurious oscillations may be strongly influenced by model specification and discretization.
Various numerical results are evaluated through this work consisting of transportation networks of different sizes (vary between small to medium size transportation networks). The detailed results analysis illustrates the model ability to depict realistic traffic behavior and to provide additional insights.

Avi Herbon, Yuval Hadas

Generalized Newsvendor Model for Determining Public-Transit Route's Optimal Frequency and Vehicle Capacity

Public-transit route's level of service is highly affected by the frequency and vehicle capacity. The combined values of those variables contribute to the costs associated with the route's operations as well as to the costs associated with passengers comfort, such as waiting and overcrowding. We introduce a new approach to the problem which combines passengers' costs and operators' costs within a generalized newsvendor model. From the passenger perspective, waiting and overcrowding costs are used, while from the operators perspective, vehicle size related costs, empty seats, and lost sales are used. The advantages of the newsvendor model are related to: a) treating the costs as shortage (overcrowding) and surplus (empty seats), b) simultaneous optimal results for both frequency and vehicle size, c) efficient and fast algorithm, and d) flexible calibration of the cost functions. We demonstrate the usefulness of the model through a case study and sensitivity analysis.

Lauren M. Gardner, Stephen D. Boyles, Hillel Bar-Gera, Kelly Tang

Robust Tolling Schemes for High-Occupancy/Toll (HOT) Facilities Under Variable Demand

High-Occupancy/Toll (HOT) lanes have become an increasingly prevalent form of congestion management pricing in the U.S. and in Israel over the past few decades. The success of a HOT facility is dependent on the pricing scheme implemented, which determines the utilization of the HOT lane, and the corresponding congestion relief on the parallel general-purpose (GP) lanes. An additional complexity in determining HOT tolls arises from the inevitable variability in travel demand, which is inherent to transport networks. A successful tolling scheme, whether fixed or time-varying, must therefore be robust to changes in travel demand. In this paper we examine various tolling schemes for HOT facilities in efforts to identify robust pricing policies. The expected performance and corresponding variability of the facility is evaluated under each pricing scheme for different demand profiles.
The focus of this paper is on non-correlated demand uncertainties (i.e. the number of arrivals during a given time interval is independent of the number of arrivals in the preceding and following time intervals), which we model by

considering the number of arrivals in each minute as independent random variable with known distribution and time-of-day dependent mean. The performance model for a given demand realization is deterministic.
The results show that a fixed toll can achieve about two thirds of the benefit of an ideal HOT system. The performance of a pre-scheduled toll system is between the fixed toll and the ideal system: closer to the ideal when the coefficient of variation is below 40%, and closer to the fixed toll otherwise. A relatively simple real-time system, with density-based linear adjustment to the pre-scheduled toll, has practically equivalent performance to the ideal system.

Operations Management 1 - Chair: Yigal Gerchak

Tal Avinadav, Avi Herbon, Uriel Spiegel

Optimal ordering and pricing policy for demand functions that are separable into price and inventory age

We formulate and analyze two models for determining the optimal pricing, order quantity and replenishment period for items whose demand function is separable into components of price and inventory age. The first model assumes a multiplicative demand function. We provide conditions, which are satisfied by most common price-dependent demand functions, to reduce the three-variable profit maximization problem into a single-variable problem, which can be solved using an efficient line-search method. Next, we show that a genuine additive model cannot exist, and instead suggest and analyze a pseudo-additive model. However, this model is more limited than the multiplicative model in its ability to incorporate various combinations of price and inventory age effects, and reduction of the maximization problem into a single-variable problem is more complicated, except in the case of a linear price effect, which is further analyzed. For both models, we show that the optimal solution satisfies the first-order condition for equilibrium under a monopoly, with a modification that includes inventory holding costs. We solve numerical examples to illustrate the solution procedures.

Tal Avinadav, Tatyana Chernonog, Yael Perlman

Analysis of Protection and Pricing Strategies for Digital Products under Uncertain Demand

We analyze pricing and protection (digital rights management) strategies in a two-echelon supply chain that consists of a manufacturer and a retailer of digital products. The demand for the legal (non-pirated) product, which depends on both price and monetary investment in protection, is assumed to be uncertain. Three different supply chain models are analyzed: manufacturer Stackelberg, retailer Stackelberg and vertical integration. We show that the retailer's utility function has no effect on the equilibrium strategies, and suggest schemes to find these strategies for any utility function of the manufacturer. Further results are obtained under assumptions of either a multiplicative or an additive demand model. We study the players' strategies under different profit criteria reflecting different attitudes toward risk—specifically, the Expectation criterion and the Target criterion—and, for each criterion, we obtain the dependence between the pricing and the protection investment. We show that there are situations in which the manufacturer can increase his profit by giving up his leadership to the retailer, even if the power balance is in his favor.

Yossi Hadad, Baruch Keren

An economic partition of a given number of machines among operators

This paper explores a special case of the machine interference problem where the service rate is random and where the interference is calculated according to the binomial distribution. The paper proposes a method to determine the optimal number of operators to be assigned to a given number of identical machines, as well as the number of machines that will be run by each operator (a numerical partition). This determination should be made with the objective of minimizing production costs or maximizing profits. The optimal assignment is calculated by transformation of the partition problem into a problem of finding the shortest path on a directed acyclic graph. The method enables us to calculate the adjusted cycle time, the workload of the operators, and the utility of the machines, as well as the production yield, the total cost per unit, and the hourly profit for each potential assignment of operators to machines. The paper provides formulas and tables that give machine interference rates through the application of binomial distribution. A real-life case study illustrates the applicability of the method.

Simulation - Chair: Itzhak Benenson

Gennady Waizman, Shraga Shoval, Itzhak Benenson

Micro-Simulation of the Car-Pedestrian Road Accidents

Data on traffic accidents clearly points to road black spots, where the accident rate is always high. However, road safety research is still far from understanding why this particular place on a road is risky. The reason is the lack of modelling how pedestrians and drivers interact when facing a potentially dangerous traffic situation, and the lack of an integrated framework, that relates the data on human behavior to real-world traffic situations. We attempt to tackle this problem by developing SAFEPED, a multi-agent microscopic 3-D simulation of vehicle and pedestrian dynamics at a black spot.
SAFEPED is a test platform for evaluating experimentally estimated drivers' and pedestrians' behavioral rules, and estimating accident risks in different traffic situations. It combines a continuous representation of space with the simulated motion of drivers and pedestrians that utilizes comprehensive robotic techniques of obstacle avoidance. We apply this innovative approach for a universal description of mixed vehicle/pedestrian motion in a continuous space for the study of road safety at black spots. SAFEPED is a spatially explicit agent-based model that represents traffic spot infrastructure and moving objects in fine 3D details, and operates at a high time resolution of 1/25 of a second. Behavioral rules of SAFEPED agents – vehicles and pedestrians are based, when possible, on the experimental data.
To validate SAFEPED, we compare the performance of the real and simulated agents in a road-crossing event, in which two pedestrians cross the road in front of an approaching car. The comparison is based on analysis of video record of the event. We qualitatively compare the performance of agents in simulated scenario in which the driver agents approaching crosswalk, subject to road constraints, must react to crossing pedestrians.
We present the main features of the SAFEPED model, the results of the validation and verification tests. We also present SAFEPED's potential for analyzing the design of existing and future black spots and to assess alternative architectural and environmental solutions in order to identify maximally efficient safety countermeasures.

Tamir Balasha, Tomer Toledo

Simulation-based Optimization of Actuated Traffic Signal Plans

Transportation systems face increased congestion. Congestion limits mobility and results in negative economic impacts. Traffic signal control is the main tool for transportation systems operators to allocate capacities and affect the system performance. The design of traffic signal control is recognized as a cost effective method to improve accessibility and mobility in urban networks. However, inadequate design of signal plans may prohibit realizing their potential to alleviate congestion.
Signal control has evolved over the years from pre-timed plans to actuated plans that utilize detection technologies and are sensitive to variations in traffic demand. The complexity of traffic signal plans has increased further with the introduction of additional features, such as transit priority or pedestrian and bicycle phases and actuation. Thus, signal plans are increasingly complex with sophisticated logical conditions and constraints, and contain a large number of parameters that need to be carefully set. As a result, the problem of setting optimal parameter values becomes analytically intractable, which further contributes to the difficulty to design signal plans.
This paper presents an optimization program that can be used with complex actuated signal plans. The program utilizes a mesoscopic traffic simulation model, which is computationally efficient compared to the microscopic models that have been used for this purpose in the past. At the same time, it maintains the level of detail required in order to model the characteristics of actuated signal plans, including features of transit priority and pedestrian actuation.
The overall simulation-based optimization framework incorporates components of the signal plan, traffic simulation and optimization algorithm. The simulation model and the signal plan function are run simultaneously. The traffic simulator advances the vehicles in the system. It provides the control logic with information on the detector states. These are used at each time step, to determine the traffic lights settings, which in turn affect the movement of vehicles in the simulation. The traffic simulation also calculates performance measures, which are used by the implemented optimization method to determine new parameter values. These are transferred to the control logic to be used in subsequent simulation runs.
The mesoscopic simulation model represents individual road users, including passenger cars, transit vehicles and pedestrians explicitly. Vehicle movements are modeled by events occurring at detector locations and the stop line. A vehicle enters the system at the time it arrives at the furthest detector location (or at the stop line if there are no detectors). At this point, its travel time to the next detector or the stop line is determined based on the approach speed. When a vehicle arrives at the stop line, it is placed in a vertical queue for the lane it is on. Vehicles are released from these queues in a FIFO manner at a rate based on the approach saturation flow and the signal indication. Pedestrians arrive at the crosswalks randomly with an arrival rate provided as input. They are assumed to activate a pedestrian crossing button at the time of arrival. The simulation implementation is time-based with a step size of 1 second in order to fit with the resolution of the control logic.

The optimization program is demonstrated with a case study for an intersection in Haifa, Israel. The control of this intersection is a fully actuated plan with transit priority for a BRT line that crosses the intersection in both directions. In addition, there are seven vehicle movements and seven pedestrian crossings that are organized in three signal phases. The optimization was conducted for 14 of the control logic parameters, using an objective to minimize the delay per passenger. For the optimization, a Genetic Algorithm with a population of 100 points in each of 30 generations was used. Each point was evaluated by 20 replications, thus requiring a total of 60,000 simulation runs. The optimization program required approximately five hours to run. A comparable optimization based on microscopic traffic simulation would not be computationally feasible. The results showed a substantial improvement in the signal plan design. The average passenger delay reduced by 38%, from 16.3 to 10.1 seconds.

Nadav Levy, Itzhak Benenson

Modeling car parking in the city – What is easy and what is complicated?

Urban traffic models focus on vehicles driving from origins to destinations, but take it for granted that the driver would eventually park. This is not always true. Parking is a critical component of a trip and the lack of parking, or wrong parking policy can be the reason of long cruising for parking, traffic jams, and failure of the entire urban transportation policy. Transportation research, today, still lacks practical tools and methodologies for analyzing parking needs and dynamics.
We propose a model-based approach for parking management and policy-making in the city and present a series of models of the parking phenomena at different levels of spatio-temporal aggregation. These models are currently being applied in several cities in the world.
The main problem of parking planning and management is spatial heterogeneity of the parking demand and supply. The proposed models explicitly deal with the heterogeneity of the urban space, and, also with drivers' competition for parking space. The first model, PARKAGENT, is a dynamic spatially explicit simulation model of parking search in the city. The second model, PARKFIT, is a static model that enables estimation of the PARKAGENT steady parking patterns. These simulation models are accompanied by the mean field analytical model that provides estimates for the spatially homogeneous situations. We employ the models for studying parking policy alternatives, assessment of large parking garage construction projects and estimating the effectiveness of various practices of parking management (sensors, cameras, human control).
Tight coupling between GIS data and spatially explicit high-resolution predictive simulations is a growing use in transportation management and policy-making. However, models per se are insufficient. A socially-oriented modeling that aims at real-world application must be based on simple but robust formalization of human behavior and on an easy methodology for estimating model parameters. We thus present a methodology of field data collection and experiments that makes our parking models applicable in the real-world case studies.

Health Care Applications - Chair: Joseph Pliskin

Guy Wachtel, Amir Elaluf, Eugene Levner

An alternative scheduling approach for improving the emergency department performance

Hospital crowding and the impact on patients admitted through the emergency department have received increasing attention in recent years. Stories such "Emergency Room Gridlock: On the Verge of Crisis" have become almost commonplace in newspapers all over the world.
This paper proposes an alternative approach where patient's length of stay (LOS) is limited by a given value, according to ED's management decision; this value is known to the patient and should decrease his/her ambiguity. The physician schedule is attained according to the given restriction and patient attributes. In the case when not all of the patients can be treated on time, the patients are divided to two groups, full diagnostic group and partial diagnostic group. The second group, after partial diagnoses in the ED will be sent to other department and known as ED's floating patients. Finding the optimal or approximate schedule is done by executing a pseudo-polynomial algorithm or an ε-approximation algorithm respectively.
In the first problem introduced in the paper, patient attributes are assumed to be known. In the second problem, the patient's attributes are unknown, the physician diagnoses the patients in two stages, a preliminary test that should estimate patient attributes and then full diagnoses that should obtain where the patient should go next. The second problem is covered by using the algorithms constructed for the first problem combined with a halting rule.
The proposed algorithms were tested using a simulation with real-life data (observed and collected from the ED of Bnei-Zion Hospital in Haifa). It was found that by selecting the appropriate scheduling of the patients' examinations, the ED's profit increased, the patients' LOS was shortened thereby raising the quality of patient-care and patient satisfaction.

Carri W. Chan, Galit Yom-Tov

Managing Healthcare Systems: Speedup versus Admission Control

In a number of service settings, waiting, admission control and speedup of service rates have been used to manage periods of congestion. In a healthcare setting, this means that patients who require care may be sent to other, less ideal service outlets. This comes at a cost to patient outcomes. In this work, we examine a multi-server queueing system which allows for admission control and speedup. We use dynamic programming to characterize properties of the optimal control and find that in some instances, the optimal policy has a simple form of a threshold policy. Leveraging this insight, we do performance evaluation of a queueing system where speedup is used when the queue length exceeds some threshold and admission control is used when the queue length exceeds some (potentially different) threshold. Using fluid analysis and a Loss model, we establish approximations for the probability of speedup and admission control and the expected queue length. We use the approximation analysis to characterize the region of the optimal solution, and develop a greedy heuristic to derive a near-to-optimal solution to original optimization problem. We use simulation to demonstrate the quality of these approximations and find they can be quite accurate. This analysis can provide insight to system administrators as they evaluate different admission and speedup control policies.

Dan Yamin, Arieh Gavious, Eyal Solnik, Nadav Davidovitch, Ran D. Balicer, Joseph S. Pliskin

An Innovative Influenza Vaccination Policy: Targeting Last Season's Patients

Background: Vaccination is the most efficient and cost-effective method to prevent influenza, reducing morbidity and mortality rates not only for those vaccinated, but also for the entire population. In the context of contact network epidemiology, an individual who is located in the center of the network is more likely to become infected. We show that targeting last season's patients can substantially decrease the influenza burden.
Methods: We used the Susceptible-Infected-Recovered (SIR) compartmental mathematical model, and ran 2,100,000 simulations, each reflecting two successive influenza seasons over large scale contact networks. In the first season no manipulation has been made. The second season was tested with a Random Vaccination Policy (RVP) and a vaccination policy Prioritizing those who were Infected in the Previous season especially before the peak (PIP). To validate the simulation results, we analyzed influenza-like data provided by the two largest Health Maintenance Organizations (HMOs) in Israel, covering more than 74% of the Israeli population, during 2003-2012.
Results: Contact network epidemiology simulations show that implementing the PIP policy is more effective in reducing morbidity than RVP even when considering partial protection (cross-reactivity) due to previous exposure that is as high as 50-60%. Along the same line, the empirical data obtained from medical records showed for every year tested, for each HMO, for each interpretation of what is considered a case of influenza, and regardless of age, that last season's patients' relative risks to become infected are substantially higher than 2.
Conclusions: No CDC recommendations have ever considered the effect of a previous season on an individual in determining a future vaccination policy. The PIP can be achieved easily by sending pamphlets, telephone reminders or even family physician recommendations to those who were diagnosed by the family physician as suffering from influenza-like illness (ILI) in the previous season.

Game Theory 1 - Chair: Ella Segev

Shiran Rachmilevitch

The Nash solution is more utilitarian than egalitarian

I state and prove formal versions of the claim that even though the Nash (1950) bargaining solution offers a certain reconciliation of fairness and efficiency considerations (egalitarianism vs. utilitarianism), it puts more emphasis on the latter rather than on the former. Additionally, I extend the Nash bargaining model by assuming that utility can be transferred between the players, but that doing so has some cost (the traditional settings of transferable utility and non-transferable utility are polar cases of this more general model, ones where the transfer cost is zero and infinity, respectively); I use this augmented model to better understand the connection between utilitarianism and Pareto efficiency.
I also introduce two new concepts into the bargaining framework: the price of fairness and the price of efficiency which are used to further study the egalitarianism-vs-utilitarianism tension.

Igal Milchtaich

Polyequilibrium

Polyequilibrium is a novel generalization of Nash equilibrium that is applicable to any strategic game, whether finite or otherwise. It differs from equilibrium in specifying strategies that players do not choose and by requiring an (after-the-fact) justification for the exclusion of these strategies rather than the retainment of the non-excluded ones. Specifically, for each excluded strategy of each player there must be a non-excluded one that responds at least as well to every profile of non-excluded strategies of the other players. A polyequilibrium's description of the outcome of the game may be more or less specific, depending on the number and the identities of the retained strategies. A particular property of the outcome is said to hold in a polyequilibrium if it holds for every profile of non-excluded strategies. Some of these properties may not hold in any Nash equilibrium in the game. In this sense, the generalization proposed in this work extends the set of justifiable predications concerning a game's possible outcomes.
Subgame perfect polyequilibrium is a refinement of polyequilibrium that applies to dynamic games and generalizes subgame perfect equilibrium. Unlike the latter, which must specify optimal actions for all information sets, many of which may lie far off the equilibrium path, a subgame perfect polyequilibrium may make do with excluding certain actions only in a relatively small number of "relevant" information sets. In particular, there may be a well-defined (subgame perfect) polyequilibrium path even if, at most information sets, no actions are excluded. Thus, in a dynamic context, the generalization of the equilibrium concept into polyequilibrium, which entails moving from a single strategy profile to a set of profiles, may paradoxically lead to solutions that are easier to find, present and verify.

Yizhaq Minchuk, Aner Sela

All-pay auctions with multiple prizes under complete and incomplete information

We study all-pay auctions with multiple prizes. The players have the same value for all the prizes (complete information) except for one prize for which each player has private value (incomplete information). We characterize the equilibrium strategy and analyze the effect of the distribution of the players' private values and the number of prizes on their expected payoffs. In particular, in contrast to the standard models of all-pay auctions with multiple prizes under incomplete information, we identify conditions under which increasing the number of prizes decreases the players' ex-ante expected payoff. Thus we may conclude that a larger number of prizes does not necessarily benefit the players in a contest.

T2

Scheduling 1 - Chair: Michal Penn

Chen Kaminer, Hussein Naseraldin, Liron Yedidsion

The Common Due-Date Assignment Problem in Scheduling: A Robust Optimization Approach

Scheduling is a crucial aspect of operations control, be it in manufacturing or in service. The need to shrink Time-To-Market, subject to the inherent uncertainties in the input data, and the need to increase service levels necessitate efficient scheduling. There are various types of scheduling problems that the decision maker faces. Among others, the Due Date Assignment Problem (DDAP), in which the objective is to minimize the cumulative jobs' earliness, tardiness, and due date assignment costs. Classic DDAP models refer to jobs' processing times as deterministic. However, for practical purposes, jobs' processing times vary due to uncertainties in the input data, e.g., machine break; the operator is newly hired and is exploring his learning curve; exogenous factors such as weather, among others. In most cases it is hard to predict in advance the distribution of the processing time. To cope with the hurdle posed by these uncertainties, Robust Optimization has been emerging as a promising methodology to solicit robust solutions that immunize the system against the various realizations of the uncertain input data.
In this research we focus on uncertain DDAPs by utilizing the notions of the Robust Optimization methodology. We consider the uncertain case of the DDAP with single machine, in which the job processing time is uncertain. The scheduler has to determine the jobs' due dates and sequence so as to minimize the total earliness, tardiness, and due date penalties. We focus on one of the most studied DDAP models where all jobs share a COmmoN due date, thus denoted by CON. We show that for a given sequence, finding the optimal common due date that would minimize the worst case scenario could be achieved in polynomial time with a help of an oracle that reveals to us the number of tardy and early jobs in the worst case scenario. In this stage of our research it is still an open question whether or not the problem is solvable without the help of the oracle.

Tal Shusterman

Weighted Throughput in a single machine preemptive scheduling with continuous controllable processing times

We consider the problem of weighted throughput in the single machine preemptive scheduling with continuous controllable processing times. A set of n tasks are to be scheduled on a single machine. Each task is associated with a weight w_j , a release date, a due date, and a range of possible processing times. All of the parameters are assumed to be non negative integers. The processing of a task can be preempted, that is, to be interrupted and resumed later. The reward for processing task j for a total of p_j time units (where p_j belongs to the range of possible processing times) is w_j*p_j and we are interested in maximizing the sum of rewards. We show there exists an integer optimal solution for the described problem. Next we present a dynamic programming that solves the problem in pseudo-polynomial time and propose an efficient frontier approach for improved complexity bounds.

Dvir Shabtay, Omri Dover, Moshe Kaspi

Single Machine Two-Agent Scheduling Involving a Just-In-Time Scheduling Criterion

We study a set of single machine two-agent scheduling problems where the performance measure of the first agent, F_1, is the weighted number of jobs completed exactly at the due date, i.e., completed in a just-in-time mode. The performance measures of the second agent, F_2, is either the makespan, the total completion times or the weighted number of jobs completed exactly at the due date. For each combination of performance measures of the two agents, we study four different variations of the problem. We show that all four problem variations are strongly $\mathcal{NP}$-hard for both cases where the performance measure of the second agent is either the makespan or the total completion times even if all of the first agent's weights are equal. We also study the special case of these problems where the job processing times of the second agent are all equal (while the weights of the first agent are arbitrary). For this special case we prove that three variations of this problem are $\mathcal{NP}$-hard in the instance size, while all four problem variations are polynomial solvable with respect to the number of jobs. For the problem where the performance measure of both agents is the weighted number of jobs completed at the due date, we show that one problem variation is solvable in polynomial time, while all other three variations are ordinary $\mathcal{NP}$-hard.

Dvir Shabtay, Kfir Arviv, Helman Stern, Yael Edan

A Combined Robot Selection and Scheduling Problem for Flow-Shops with No-Wait Restrictions

This paper addresses a bicriteria no-wait flow-shop scheduling problem with multiple robots transferring jobs between pairs of consecutive machines. The robots share an identical track positioned alongside the machine transfer line. Each robot is assigned to a portion of the tract from which it performs job transfers between all reachable machines. We assume that job processing times are both machine and job independent, that jobs are not allowed to wait between two consecutive machines and that machine idle times are not allowed. We define a combined robot selection and scheduling problem ($\mathcal{RSSP}$) for a set of Q non identical robots characterized by different costs and job transfer and empty movement times. A solution to the $\mathcal{RSSP}$ problem is defined by (*i*) selecting a set of robots, (*ii*) assigning each robot to a portion of the track, and (*iii*) scheduling the robot moves. We define a robot schedule as feasible if all the jobs satisfy the no-wait condition and there are no machine idle times. The quality of the solutions are measured by two criteria (performance measures); makespan and robot selection cost. We study four different variations of the $\mathcal{RSSP}$ one which is shown to be solvable in polynomial time while the other three turn out to be $\mathcal{NP}$-hard. For the $\mathcal{NP}$-hard, we show that a pseudo-polynomial time algorithm and a fully polynomial approximation scheme exists, and derive three important special cases which are solvable in polynomial time. The $\mathcal{RSSP}$ has aspects of robot selection, machine-robot assignment and robot movement scheduling. We believe this is the first time that this type of problem has been treated in the literature, and addresses a very important problem in multiple robotic systems operation. Our contribution lies in the formulation, methodology, algorithms for solution and complexity results which jointly treats all aspects of the problem simultaneously without the need to defer to heuristic decomposition methods.

Queueing 1 - Chair: Gad Rabinowitz

Ruth Shilman, Dean Grosbard, Gadi Rabinowitz, Israel Tirkel

Queueing Networks Model for Manufacturing Systems with Various Policies of Downtimes

The main objective of this work is to improve the performance prediction of manufacturing lines with downtimes events (e.g. set-up, maintenance and failures). These events, which may involve significant interference among classes, generate non-renewable flows with very high variability while causing starvation of a downstream bottleneck queues. Our approach based on combining two-moment decomposition approximations with variability function procedure suggests differentiating between two components that impact the departure distribution: the within-class

and between-class effects. For the within-class effect we employed existing combination in the literature of variability function into the decomposition procedure, while for the between-class effect, we developed a new function. This differentiation enables to model different downtime policies. In this work we focus on downtimes events with policy of FCFS order and policy of priority over the other classes, and demonstrate the heavy traffic bottleneck phenomena created in lines with such policies. Our proposed approximation has been examined versus simulation in lines with bottleneck queues under various downtimes, The results demonstrate a relative error five times smaller than the best relevant existing procedures in the literature.

Dean Grosbard, Adar Kalir

Queueing Network Decomposition in the Analysis of Fab Performance

Queueing networks being both analytical and stochastic models can be very tools when creating an initial fab model at stages when very little data is available. However, an engineer trying to analyze a working modern day fab using a queuing network model will quickly find out that there is hardly a tool set in the fab that can be closely described within the confines of queueing theory. This is due to the fact that even the most simple and common fab practices such as layer dedication or operation mix constraints contradict the basic queueing theory assumptions of identical servers and stationary while others like cascading or queue time constraints can make steady state means values intractable for even single server queues. Attempts to approximate performance measures for such complex tool sets using simplified queueing models will more often than not lead to substantial estimation errors. With all that being said, is there any use for queueing network models past the initial designing stages of the fab?

It is the opinion and conclusion of the author that though numeric results of queueing networks are often poor estimates of actual fab performance, the macro level qualitative relations between performance measures of different queues in the queueing network model offer a valuable insight into the inner mechanisms of the production flow. The application of queueing theory can provide an understanding of the manner in which changes to a single tool sets have an impact on the entire production line and are a key to interpreting observations or simulation results that would otherwise seem random or obscure.

In our presentation we will demonstrate, using examples taken from both simulation results as well as fab observations, how the application of queueing network decomposition, when performed properly, can provide an explanation for the impact of a change in a single tool set on the entire line. Furthermore, we will show how overly simplistic queueing network decomposition analysis can lead to opposite and misleading conclusions.

Shai Goren, Gad Rabinowitz, Yoav Kerner

Multi-cell inspection and repair resources allocation

In this study we address the allocation of limited inspection and repair resources among multiple heterogeneous production cells. Most importantly, both yield and flow-time, which are the two vital production performance measures, are considered. Furthermore, it is assumed that production, inspection and repair activities take random durations and are subject to errors.

Each cell is formulated, and its steady state distribution is obtained, via semi Markovian model. The multi-cell bi-criteria (yield and flow-time) problem is based on the cells solutions and solved through a customized non-linear optimization algorithm. The parameters' space is analyzed for identifying solution types in terms of the exploitation of each resource (inspection and repair). Each solution type reveals insightful characteristics and requires an appropriate algorithm. The main goal of this research is to extend the above formulation and solution into a general queueing network topology.

Itai Gurvich, Junfei Huang, Avishai Mandelbaum

Excursion-based universal approximations for the Erlang-A queue in steady-state

We re-visit many-server approximations for the well-studied Erlang-A queue. This is a system with a single pool of i.i.d. servers that serve one class of impatient i.i.d. customers. Arrivals follow a Poisson process and service times are exponentially distributed as are the customers' patience times. We propose a diffusion approximation which applies simultaneously to all existing many-server heavy-traffic regimes: QED, ED, QD and NDS. We prove that the approximation provides accurate estimates for a broad family of steady-state metrics. Our approach is "metric-free" in that we do not use the specific formulas for the steady-state distribution of the Erlang-A queue. Rather, we study excursions of the underlying Birth-and-Death process and couple these to properly defined excursions of the corresponding diffusion process. Regenerative-process and martingale arguments, together with derivative bounds for solutions to certain ODEs, allow us to control the accuracy of the approximation. We demonstrate the appeal of universal approximation by studying two staffing optimization problems of practical interest.

Stochastic Models - Chair: David Perry

Yonit Barron

An (s,k,S) Fluid Inventory Model with exponential lead time and order cancellations

We consider a stochastic fluid inventory model for a single-item infinite horizon, based on a so-called *(s,k,S)* policy, which is a refinement of the classical *(s,S)* policy. The content level $I=\{I(t):t\geq 0\}$ increases or decreases according to a fluid-flow rate modulated by an n-state Continuous-Time Markov Chain (CTMC). I starts at $I(0)=S$ but is not bounded from above; Whenever *I(t)* drops to level *s*, an order is placed to take the inventory back to level *S*, which the supplier will carry out after an exponential leadtime. However, if during the leadtime the content level reaches *k* the order is suppressed and a penalty cost is paid. Four types of costs are considered: the set-up cost, the variable delivery cost, the holding cost for the stock and the shortage cost for the backlogged demand. We obtain explicit formulas for these cost functionals in the discounted case. The derivations are based on optional sampling of a multi-dimensional martingale and on fluid flow techniques.

Esther Frostig

The moments of the discounted loss and the discounted dividends for a spectrally negative risk process

Consider a spectrally negative risk where upon ruin the deficit is immediately paid and the process restarts from level 0. When the process reaches a threshold *b*, all the surplus above *b* is paid as dividend. Applying the theory of exit times for spectrally negative Lévy process and its reflection at the maximum and at the minimum we obtain recursive formulas for:
1. The moments of the discounted loss until the process reaches *b*. This is equivalent to the moments of the discounted dividends in the dual model.
2. The moments of the discounted loss for model with and without dividend barrier for the infinite horizon.
3. The moments of the discounted dividends for the infinite horizon.

Onno Boxma, David Perry

A useful Pollaczek-Khinchine type equation with applications to closed stochastic storage systems in operations research

We introduce a useful key integral equation of the Pollaczek-Khinchine type and apply it to certain classical closed stochastic storage systems. The solution of the key equation in its generalized form leads to the steady state results of some prototype closed systems in operations research. The main motivation is applied to some versions of the (S -1, S) storage models, but the analogy to the Erlang loss model of the M/G/S/S queue and S machines interference models with random breakdowns and repairs are obtained as by-products of the analysis.

Optimization 1 - Chair: Hagai Ilani

Shimrit Shtern, Aharon Ben-Tal

A Semi-Definite Programming Approach for Robust Tracking

Tracking problems are prevalent in the present day GPS and video systems. The problem of target tracking is a specific case of dynamic linear system estimation with additive noise. The most widely used filter for these systems is the Kalman Filter (KF), which assumes some knowledge of the underlying statistical properties of the noise. An alternative approach is the so called *robust estimation*, which usually assumes bounded noise, and guarantees a good worst case performance. Such filters include H_∞ filters and set-value estimators (SVE). SVE is usually derived analytically using ellipsoid calculus, assuming either bounded one step update or cumulative noise update. We present an innovative SVE which is obtained through a Semi-Definite Programming (SDP) problem and guarantees an $\pi/2$ approximation with respect to the optimal SVE filter. We prove that, though our formulation takes the entire noise history into account, the problem can be solved by an iterative interior point method and is practically tractable even for long time horizons. We extend the framework to include the case of partially statistical noise, thus combining the KF and SVE frameworks. A variation of this filter which applies a rolling window approach can then be obtained, achieving fixed computational cost per-iteration, as well as coinciding with classical SVE when window size is one. Numerical examples show the advantages of this filter when dealing with adversarial noise and that the performance is not significantly affected if the rolling window size is chosen properly.

Baruch Mor, Gur Mosheiov

Single machine batch scheduling with two competing agents to minimize total flowtime

We study a single machine scheduling problem, where two agents compete on the use of a single processor. Each of the agents needs to process a set of jobs in order to optimize his objective function. We focus on a two-agent problem in the context of batch scheduling. We assume identical jobs and identical (agent-dependent) setup times. The objective function is minimizing the flowtime of one agent subject to an upper bound on the flowtime of the second agent. As in many real-life applications, we restrict ourselves to settings where the batches of the second agent must be processed continuously. Thus, the batch sizes are partitioned into three parts, starting with a sequence of the first agent, followed by a sequence of the second agent, and ending by another sequence of the first agent. In an optimal schedule, all three are shown to be decreasing arithmetic sequences. We introduce an efficient $O(n^{3/2})$ solution algorithm (where n is the total number of jobs).

David Raz, Ariel Daliot

A Practical Approach for Large Scale Optimal Pump Scheduling with Operational Constraints

Energy costs, and in specific, energy used by pumps to extract water and to deliver it, comprises the largest component of the operational costs of most water distribution systems. It is therefore much desired to optimize the operation of water distribution systems through the scheduling of pumps and other elements, to take advantage of time-varying energy tariffs and minimize energy costs. However, mainly due to the non-linear nature of the system and to the complexity of operational constraints involved, optimizing the operation of large and interconnected water distribution systems, with operational constraints, usually results in highly nonlinear or mixed integer optimization problems, which are impractical for large setups, especially where near real time operation is required.
We propose an approach to solve the problem, involving a simple iterative heuristic and a linear programming model. The linear model solves the problem without some of the operational constraints, while the heuristic sets operational constraints iteratively and resolves infeasibilities caused by previous steps. The approach is demonstrated and evaluated on a practical setup. We show that the method proposed achieves close to optimal results, at reasonable computation resources. An extension for the case of more complex cost structure, involving multiple electricity suppliers with aggregative costs is also presented. This extension can be used for optimizing water distribution systems at the national level.

Hagai Ilani, Elad Shufan, Tal Grinshpoun

A (non-trivial) two-destination transportation problem

We present a special case of the dial-a-ride problem (DARP) with two destinations. The problem is motivated by a transportation service between two academic campuses. It can also be applied to other shuttle services (e.g., between an airport and a hotel) and to the problem of transmitting freight cars between two railway stations. Two types of passenger requests are considered – s-type requests have a departure deadline, while r-type requests are constrained by release times (after which the passenger can depart). We define a time window by treating s-type and r-type requests differently. However, rather than taking the time window parameter (either deadline or release times) as a constraint, we inject it into the objective function in order to reflect passenger dissatisfaction. The objective function that DARP researchers commonly refer to is the total passenger ride times. The fact that we consider a problem with only one route (in two directions) enables us to treat customer dissatisfaction in a more refined manner. Thus, the objective is to minimize the waiting time of passengers. The problem is mathematically modeled. A polynomial algorithm (in the number of passengers) is given. The algorithm is based on a reduction to a shortest path problem, which is inspired by previous work of Prof. Uriel Rothblum.

Continuous Optimization - Chair: Amir Beck

Ron Shefi, Marc Teboulle

A Dual Method for Minimizing a Nonsmooth Objective over One Smooth Inequality Constraint

We consider the class of non-differentiable convex problems which minimizes a nonsmooth convex objective over a single smooth constraint. Exploiting the smoothness of the feasible set and using duality, we introduce a simple first order algorithm proven to globally converge to an optimal solution with a $O(1/\varepsilon)$ efficiency estimate. The performance of the algorithm is demonstrated by solving large instances of the convex sparse recovery problem.

Amir Beck, Yakov Vaisbourd

Optimization Methods for Solving the Sparse PCA Problem

Sparse principal component analysis (PCA) address the problem of finding a linear combination of the variables in a given data set with sparse coefficient vector that maximize the variability of the data. This model enhances the ability to interpret the principal components and is applicable in a wide variety of fields including genetics, finance and machine learning, just to name a few.
Sparse PCA is a hard problem, and as such, it does not possess a global optimality criterion. Thus, the algorithms proposed in the literature are seeking to solve some relaxation of the original formulation or provide an approximate solution. Commonly, such a solution will satisfy some necessary optimality condition. In the present work we consider some of the aforementioned conditions and the corresponding algorithms. We suggest a coordinate wise (CW) condition and establish a theoretical justification that an algorithm that converge to a point satisfying this condition is more likely to produce the optimal solution. We provide a numerical study that supports our assertion.

Yoel Drori, Shoham Sabach, Marc Teboulle

An $O(1/\varepsilon)$ Algorithm for a Class of Nonsmooth Convex-Concave Saddle-Point Problems

We introduce a novel algorithm for solving a class of structured nonsmooth convex-concave saddle-point problems involving a smooth function and the sum of finitely many bilinear terms and nonsmooth functions. The proposed method is simple. It uses only one gradient of the smooth term, one proximal map of each nonsmooth part, and matrix-vector multiplication per iteration. We prove that the proposed algorithm globally converges to a saddle-point with an $O(1/\varepsilon)$ efficiency estimate. We illustrate its relevance for tackling a broad class of composite minimization problems and its performance through numerical examples for the image deblurring problem and for the fused lasso logistic regression problem.

Amir Beck, Nadav Hallak

On the Minimization Over Sparse Symmetric Sets

We consider the problem of minimizing a general continuously differentiable function over symmetric sets under a sparsity constraint. We investigate both stationarity-based optimality conditions as well as conditions of a coordinate-wise type, and show, by exploiting various symmetry properties, how to verify and attain points which satisfy the derived optimality conditions. For that purpose, we also develop algorithms or expressions for the orthogonal projection operator onto sparse symmetric sets. The algorithms and optimality conditions are illustrated by examples.

Wednesday 23.4

W1

Transportation 2 - Chair: Tal Raviv

Nicole Adler, Alfred Shalom Hakkert, Tal Raviv, Mali Sher

The traffic police location and schedule assignment problem

The traffic police routine patrol vehicle mission is to provide service to the public, primarily through enforcement of traffic laws and assistance to road users after accidents or other calls for service. Efficient routine patrol vehicle placement across the road network ensures that the traffic police undertake their mission effectively. In the search for effective road network covering solutions, a multiple objective linear programming (MOLP) formulation is developed with three distinct objectives. The objective functions maximize (1) traffic police presence and conspicuousness, (2) police presence at blackspots where frequent traffic offences occur, and (3) the time available for pro-active work. In a second stage analysis, we explore the results of the MOLP formulation further. A MAXMIN integer linear program and an integer linear program, accounting for the distance and time halo effects respectively, produce a detailed, daily shift schedule across the planning horizon. Consequently, we formulate a routine traffic police schedule-location and activity problem, which incorporates road safety recommendations drawn from the literature, police policy and operational constraints. Thus, we provide a new methodology for constructing traffic police force work plans. Finally, we apply the modeling approach to a case study of the interurban road network in Northern Israel. The final results of the case study improve the overall performance of the traffic police routine patrol vehicles compared to the present location choices by increasing the current 80% coverage to full coverage, increasing presence and conspicuousness to five times the current levels and doubling the enforcement time at blackspots.

Inbal Haas, Shlomo Bekhor

An optimization model that accounts for interdependencies between groups of infrastructure related projects

In this paper we concentrate on estimating the overall travel time benefit derived from implementing groups of transportation infrastructure projects. Decision makers are often faced with the need to find the most beneficial set of projects that will maximize the overall benefit. This benefit is usually comprised of several aspects like decreasing travel time, increasing safety and taking into account environmental impacts.
In principle, if the benefits of each project can be estimated, then a general optimization model can be formulated and solved. However, the estimation of the individual project benefit is not a trivial task. This is due to the interdependencies a project has with other projects selected for implementation, and that often affect the final set of selected projects, as was already shown in previous studies.
Determining the interdependencies between different projects is a very challenging task. That is because when concentrating on different aspects the interdependency may change its character. Implementation of two projects may increase the overall benefit when considering one aspect, and may decrease the overall benefit when considering another. In addition, the interdependency itself is not easily quantified, and in many cases can be described using rough estimations only. In this paper a concentration is made on estimating the travel time benefits arising from the implementation of groups of transportation infrastructure projects.
The method presented in this paper is based on the traffic assignment model. Since the number of combinations between projects rises exponentially, a heuristic is needed to confine the number of assignment runs. An hypothesis was raised, according to which, when considering a project with a potential of decreasing the total travel time, the benefit of a single project is limited by the contribution of a project on an empty network, and its contribution when all other projects are already implemented and it is the last project to be implemented. It was further assumed that these two values determine the total benefit when a group of projects is implemented.
The above hypothesis is tested using a test network. For each project, the minimum time saving and the maximum time saving are calculated. Later on, the overall benefit gained from implementing group of projects is calculated. The results supported the hypothesis raised, and revealed that the expected travel time saving is within the expected boundaries set by the individual projects. Hence, by calculating the travel time in a very limited number of network configurations, an estimation could be determined regarding a wide range of cases.
The contribution of this paper lies in its ability to address the issue of project interdependencies while taking advantage of the information gained from traffic assignment. The method presented can assist in supplying an evaluation of the overall travel time saved as a result of implementing group of projects in a relatively little effort, and therefore can be used by decision makers for making informed decisions regarding transportation projects selection.

Nicole Adler, Xiaowen Fu, Tae H. Oum, Chunyan Yu

Air Transport Liberalization and Airport Slot Allocation: The case of the Northeast Asian Transport Market

We develop a differentiated Bertrand high speed rail and airline network game which analyzes the effects of international air transport liberalization, regional open skies policies, domestic inter-modal competition and airport slot allocation. The model is applied to the transport market in Northeast Asia using a counter-factual approach, demonstrating the model's capability of evaluating practical policies utilizing market data observed on the routes under investigation. Our modeling results suggest that air transport liberalization will benefit both consumers and the aviation industry in the region albeit not necessarily on an equal basis across or within groups. Much of the welfare gains are derived from higher frequency after liberalization, which increases service quality hence consumer utility. Open skies policies that include pure cabotage which permit carriers to compete in the domestic markets of a foreign country, will increase competition, frequency and reduce fares below current levels. Airport slot allocation policies play an important role in the realization and distribution of potential welfare gains related to liberalization. Therefore, government agencies should implement liberalization and airport slot allocation policies jointly. In a separate analysis, similar results are found for Israel too.

Approximation Schemes - Chair: Danny Segev

Nir Halman

Approximation Schemes for Sample-Based Non-linear Newsvendor

We present a framework for obtaining provably near-optimal approximation schemes for the newsvendor problem when data about the (not necessarily linear) cost functions is given via oracle calls and data about demand is deduced via samples.

Retsef Levi, Thomas Magnanti, Yaron Shaposhnik

Scheduling with Testing

We study a new class of scheduling problems, where job lengths are a priori stochastic. The scheduler can use machine time to test jobs and gain better information on the respective lengths. This captures a common practical tradeoff of allocating resources between diagnostic that improves information and allows better scheduling, and doing work. We use a new cost-accounting scheme to characterize properties of optimal policies and devise a surprisingly low dimensional DP formulation and FPTAS.

Danny Segev

An Approximate Dynamic-Programming Approach to the Joint Replenishment Problem

I will present a high-level view of a recent approach for ϵ-approximating the joint replenishment problem, with stationary demands and holding costs. Based on synthesizing ideas such as commodity aggregation, approximate dynamic programming, and a few guessing tricks, it turns out that one can attain any required degree of accuracy in quasi-polynomial time.

Queueing 2 - Chair: Moshe Haviv

Efrat Perel, Uri Yechiali

Non-Preemptive Two-Queue Polling System with Threshold-Based Switching Policy

We study a single-server non-preemptive polling-type system with two non-identical and separate Markovian queues having buffer-sizes $C_1 < \infty$ and $C_2 = \infty$, respectively. The server alternates between the queues following a threshold-based policy which, *in contrast to other threshold models*, is determined by the state of the queue which is *not* being served. Specifically, whenever the server attends queue i (Q_i) and the number of customers in the other queue, Q_j $(i, j = 1,2;\ j \neq i)$, reaches its threshold, the server switches to Q_j , but only after service completion of the presently served customer in Q_i (non-preemptive policy). If at a called-for switching moment from Q_i to Q_j the number of customers in Q_i is still above its threshold level, the server remains in Q_i until the first moment thereafter when the queue size there reduces bellow its threshold level. When a served Q_i becomes empty we consider two scenarios: (*i*) if Q_j is not empty, the server immediately switches to Q_j (work-conserving), and (*ii*) the server remains in Q_i until Q_j

reaches its threshold level (non-work-conserving). We analyze the two scenarios by using both Probability Generating Functions and Matrix Geometric methods, and reveal a direct relation between the two analysis approaches.

Nir Perel, Uri Yechiali

The Israeli Queue with Retrials

The so called 'Israeli Queue' is a single-server multi-queue polling system, where service is given in un-limited size batches. Service time of a batch is independent of its size, and the next queue to be visited by the server is the one with the most senior customer. In the presentation we discuss an 'Israeli Queue with Retrials', where the system is comprised of a main queue operating under the Israeli Queue regime, and an orbit queue. The main queue consists of at most M groups, where a new arrival enters the main queue either by joining one of the existing groups, or by creating a new group. If an arrival can not join one of the groups in the main queue, he/she goes to a retrial (orbit) queue. The orbit queue dispatches orbiting customers back to the main queue at a constant rate. We analyze the system via both Probability Generating Functions and Matrix Geometric methods, calculate analytically various performance measures, and present numerical results.

Sophie Hautphenne, Moshe Haviv

Bias-optimization in queueing models

In selecting between Markov reward processes, one usually looks for maximizing the gain per unit of time. In case of a tie, the focus turns to the bias which is then a function of the initial state. We exemplify that through a memoryless queue where the question is how many waiting places to have. We show how the number in the queue at opening effects the decision. All is done through the use of the deviation matrices of the underlying Markov processes.

Operations Games - Chair: Shoshana Anily

Roi Feldhaim, Liron Yedidsion, Gal Zahavi

Utilizing Risk Allocation for Revenue Management

Companies strive to maximize their profit using different venues e.g. Marketing, Organizational Change, Innovating products, Change of strategy and Revenue management (RM). The use of RM to profit maximization traditionally deals with optimizing pricing and delivery time of products and services. In this work we introduce a mechanism of revenue management based on allocating risk from the consumer to the service provider through a bundled insurance contract, that compensate the consumers in case of service default by the service provider.
We prove that by adding self-insurance mechanism, we improve profitability. Furthermore, additional profits can be earned by reducing the risk of damages for the consumers and finally we show that optimal service for maximum profitability doesn't imply risk free service.

Dana Sherill-Rofe, Tatiana Chernonog

Hospital – Sick Fund Contracting and Quality of Care: A Game Theoretical Approach

Although highly regulated in many countries, contracts between sick funds (SFs), as insurers, and hospitals, as service providers, have many pitfalls. One of the ways to reduce costs by SFs is to offer in-house treatments, from emergency centers replacing ERs, to services formerly offered only in out-patients wards, either by the sick fund itself or by outsourcing to private clinics. As a case study we look at two examples in Israel's health care system, which we believe are representative of many other countries. In Israel, since 1994, all citizens are insured by one of four SFs. SFs offer in house services, as well as covering hospitalization costs. Specifically, the "Clalit" sick fund insures over half of the population in Israel, and, for historical reasons, owns several hospitals in addition to other facilities. On the other hand, SFs such as "Meuhedet" do not own hospitals. There is a continual debate both in academic and general media as to the effects of contracting, regulation and payment methods on quality of care. However, till now there has been little focus on hospital-SF (insurer) interactions. As mobility between SFs is low, we believe this discussion is of great value. In this work we aim to focus on the relationships between SFs and hospitals, both attempting to offer high quality treatment but hindered by austerity.
Over the years, a large body of research has focused on the relationship between consumers (patients) and health insurers such as sick funds, discussing among others, the effects of moral hazard and cost sharing, mobility, attitude towards risk, and technology.
Ellis and McGuire (1986) developed the basic theoretical model in which physicians choose the level of services to be provided to their patients. They show that if physicians undervalue benefits to patients relative to hospital profits,

prospective payment can lead to too few services being provided. In contrast, a 'cost-based' reimbursement system is shown to result in too many services being provided. Competition between hospitals for physicians will tend to augment both of these problems.
In this work, we explore the SF-hospital contracting situation and its effect on quality of care offered to patients. We use the game theoretical approach to model this relationship, aiming specifically to learn about the effect of cooperation vs. non-cooperation on the efforts the players will put in offering higher quality of care to increase internal demand. For this purpose we use the double moral hazard framework, and base our cost functions on Randall and Ellis, 1998. We focus on medical situations where patients can choose whether to use SF facilities or go to the hospital. As we see in Israel large investments made by both SFs and hospitals to attract patients, we ask the question what motivates the players to invest, and whether it is lucrative to both organizations, and to social welfare.

Shoshana Anily

Cooperation in service systems: The 3-D assignment M/G/c/c game

We consider a cooperative game whose set of players consists of a number of M/G/c/c queuing systems that have no waiting room. Each system is associated with a Poisson arrival rate, a mean service rate, and a room size. The cost of such a system if it acts individually is the average rate of lost (blocked) customers. When a coalition of such systems is formed, its characteristic function value is minimum achievable average rate of lost customers, where the service rates and room sizes are reassigned to the arrival rates. Such a game is a 3-D assignment (bi-permutation) game, and it is clearly sub-additive, meaning that the best formation of coalitions is when all players cooperate. However, in contrast to 2-D assignment problems, the 3-D assignment problem is known to be NP-complete. We will show a few properties of general 3-D assignment games, as for example, that a 3 player 3-D assignment game is totally balanced if and only if there exists an optimal integer solution to the relaxed LP formulation of the assignment game. For more than 3 players, if the solution to the relaxed LP formulation of the assignment game is integer, then the game is balanced.
The expected rate of lost customers function for a given M/G/c/c system is known to satisfy several convexity and sub-modularity properties in its 3 parameters. These properties are helpful in excluding the possibility of certain assignment types of being optimal. Relaxing the integrality constraints and solving the 3-D assignment problem as an LP problem, produces a lower bound value (LB). If the solution of the lower bound is non-integer, integer programming software is used to get an upper bound value (UB).
An initial computational study shows that in 92.1% (67.8%) of runs with 10 (50) players, an integer solution is obtained for lower bound. If a non-integer solution is obtained, the average gap between UB and LB for 10 (50) players is 0.77% (0.0165%), and the maximum gap is 5.5% (0.0563%). The lower and upper bounds can be used to generate a cost allocation vector that may violate the core constraints by at most the gap between the two bounds, i.e., UB/LB.

Scheduling 2 - Chair: Gur Mosheiov

Enrique Gerstl, Gur Mosheiov

Single Machine Just-in-Time Scheduling Problems with Two Competing Agents

In scheduling problems with two competing agents, each one of the agents has his own set of jobs to be processed and his own objective function, and both share a common processor. In the single-machine problem studied in this article, the goal is to find a joint schedule that minimizes the total deviation of the job completion times of the first agent from a common due-date,
subject to an upper bound on the maximum deviation of job completion times of the second agent. The problem is shown to be NP-hard even for a nonrestrictive due-date, and a pseudo-polynomial dynamic program is introduced and tested numerically. For the case of a restrictive due-date (a sufficiently small due-date that may restrict the number of early jobs), a faster pseudo-polynomial dynamic program is presented. We also study the multiagent case, which is proved to be strongly NP-hard. A simple heuristic for this case is introduced, which is tested numerically against a lower bound, obtained by extending the dynamic programming algorithm.

Tal Grinshpoun, Elad Shufan, Hagai Ilani

Generalization of the rank matrix representation for shop problems

The rank matrix representation was introduced by Bräsel et al with respect to the open shop scheduling problem. We show how to extend this representation to general scenarios of shop problems, including the partially-concurrent open shop scheduling (PCOSS) problem. A PCOSS is an open shop problem with the possibility of processing some operations concurrently. We prove a one-to-one correspondence between a unique matrix, called CG-rectangle, and a semi-active schedule of a PCOSS. This generalizes Bräsel's "Latin-rectangle theorem". The rank matrix representation

is also used in an algorithm that heuristically constructs a partially concurrent open shop schedule. The scheduling problem is shown to be equivalent to a NP-Hard problem of graph orientation.

Enrique Gerstl, Gur Mosheiov

A two-stage flexible flow shop problem with unit-execution-time jobs and batching

We study a batch-scheduling problem of unit-time jobs on a two-stage flexible flowshop. The objective functions are minimum makespan and minimum flowtime. Unlike previously studied models: (i) a general number of machines in both stages of the flowshop is allowed, and (ii) there is no restriction on the number of batches to be processed on each machine. Efficient exact dynamic programming algorithms are introduced. Extensions to the case of machine-dependent setup times are studied as well. All the proposed algorithms run in polynomial time in the number of jobs.

W2

Game Theory 2 - Chair: Ella Segev

Yaron Azrieli, Eran Shmaya

Rental Harmony With Roommates

Abstract: We prove existence of envy-free allocations in markets with heterogenous indivisible goods and money, when a given quantity is supplied from each of the goods and agents have unit demands. We depart from most of the previous literature by allowing agents' preferences over the goods to depend on the entire vector of prices.
Our proof uses Shapley's K-K-M-S theorem and Hall's marriage lemma. We then show how our theorem may be applied in two related problems: Existence of envy-free allocations in a version of the cake-cutting problem, and existence of equilibrium in an exchange economy with indivisible goods and money.

Sergio O. Parreiras, Anna Rubinchik

Segregation by ability increases competitiveness in contests

We find a smooth Bayesian-Nash equilibrium in the asymmetric contest game where players know that all the rivals' abilities are distributed uniformly with commonly known support, so the players differ ex-ante by their top ability.
We show that (at least when players are not too different ex-ante) allocating players into two groups of equal size by their top ability (with all players in one group having higher top ability than in the other) yields a higher expected revenue than fully mixing the players in each of the two groups.

Irit Nowik, Shmuel Zamir

The game on the risk of deviating from the Nash strategy

In two-person zero-sum games, Nash-equilibrium points coincide with Minmax points, thus if the Nash equilibrium is unique then it makes a strong prediction for the behavior of players. Deviating from the Nash equilibrium is risky, and the degree of risk depends on the specific game matrix.
We wish to model the deviations from a Nash strategy. Deviations may be intentional, in trying to exploit a suspected deviation of the other player from his own Nash strategy. On the other hand, deviation can be accidental, a manifestation of a 'trembling hand', resulting for example from some cognitive limitation of human subjects to produce perfect randomization. Accordingly we define two models; "the Intentional-model" (or "I-model"), and "the Un-Intentional-model" (or "UI-model"). In each of the two models, we define a "risk-measure" representing, for each player, the potential risk in deviating from the Nash-play in that game.
In the I-model the row player (PI) and the column player (PII) each *chooses* the direction to deviate, and then PII pays PI the resulting difference from the Nash payoff. Hence the I-model can be viewed as a new zero-sum game, defined over the original game. We call this new game: "The game on the risk of deviation". Clearly the game on the risk does not have a value in the usual sense, as we removed the *unique* Nash equilibrium from the strategy sets (by "forcing" the players to deviate). Our main result is that the risk of PI and the risk of PII always coincide. This result holds for any norm we choose for measuring the size of the deviations. Hence, if we view the players as playing on the *risk*, then in *this* sense, the new game has a value. We prove the equality between the risks of the two players in both, the I-model and the UI-model. We develop an explicit expression for the risk measures for the $\|\cdot\|_1$ - and $\|\cdot\|_2$ -norms, in both the I- and UI-models. Although the results hold for all norms, we show that only the $\|\cdot\|_1$ -norm is suitable in our context, as it is the only norm which gives the same measure to equivalent deviations.

In recent years, experimental game theory has focused on trying to validate the predictions of game theory through classical tests of statistical hypotheses. This encounters many difficulties. For example, in repeated games, mixed strategies involve independence, however as mentioned above, human subjects cannot produce perfect randomization and thus cannot play the Nash equilibrium *exactly* (thus failing the statistical tests). Acknowledging this, Brown and Rosenthal (1990) suggest replacing the question "*Did* the players play the Nash strategy?" with the question: "*To what extent* did the players play the Nash strategy?" This view presents a weaker or wider interpretation of "playing Nash", by concentrating on the *closeness* of the play to the theory. Accordingly, the risk measures defined here enables testing and evaluating predictions, such as: Does players deviate more in games with lower risks than in games with higher risks?

Gabrielle Gayer, Ella Segev

Revealing private information in Bargaining

It is well known that bargaining with incomplete information incurs a substantial amount of inefficiency. We consider a bargaining procedure in which the seller makes a "take-it-or-leave-it" offer to a buyer. An initial stage in which the buyer is permitted to convey information to the seller is introduced into this framework. The decision regarding what information will be conveyed is made before the buyer knows his exact valuation. We study the type of information the buyer would be willing to transmit to the seller. The analysis determines that buyers with low valuations, in effect, reveal their valuations whereas buyers with high valuations conceal them. Communication between buyer and seller before the bargaining process begins improves both the overall efficiency of the process as well as the welfare of both buyer and seller.

Strategic Behavior in Queues - Chair: Yoav Kerner

Moshe Haviv, Binyamin Oz, Martin L. Puterman

Centralized Planning of Relative Priorities in Parallel Network of Queues

Service systems where heterogeneous customers choose one of many service providers to get service from are very common. Examples are patients with different needs who choose physician or retailers who need goods supplied by several suppliers. In such systems, selfish customers do not follow the socially optimal routing policy (for example, tend to overload the more attractive servers), and by that reduce the overall performance of the system, hence centralized intervention should be considered. We propose centralized planning of relative priority rules for allocating servers to demand classes so as to achieve system performance objectives as best possible.
We define a model of parallel network of queues and investigate the (not necessarily unique) Nash equilibrium under a given relative priority rule. Next, we characterize the central planner's optimal policy in two basic examples of such networks.

Refael Hassin, Alexandra Koshman-Kaz

Optimal control of a queue with high-low delay announcements

This article deals with strategic control of information in an unobservable single-server model. It considers an M/M/1 system with identical customers. The admission fee changes according to the congestion level. The firm can choose a single cut-off number, and the level of congestion is said to be low (high) if the queue length is at most (above) this value. The firm can dynamically change the admission fee according to the level of congestion, and it charges a lower fee when congestion is high. Arriving customers cannot observe the queue length, but they are informed about the current level of congestion and the admission fee.
The article deals with finding the profit maximizing cut-off value and admission fees, using analytical and numerical methods. We observe that such a pricing regime increases the total profit and is preferable over both observable and unobservable models. Moreover, the proportion of the increase in profits is unbounded.

Nahum Shimkin, Eitan Altman

A Game of Ad Submission Timing Over a Shared Display Board

We consider a model of competition between advertisers, who compete for position and exposure over a shared publication medium such as an on-line classified list. Ads are ordered according to their posting times, with more recent ads displayed at the top (and better) positions. The instantaneous effectiveness of each ad thus depends on its current display position, as well as on a common time-dependent exposure function that represents that collective exposure of the board as a function of time. It is assumed that each advertiser may choose the submission time of his ad, and wishes to maximize its total exposure. We formulate the problem as a non-cooperative game between the

advertisers (or players), where the number of participating players (the demand) is allowed to be random. For the general model we characterize the symmetric Nash equilibrium profile in terms of a certain functional differential equation, provide sufficient conditions for its uniqueness, and devise a numerical schemes for its computation. We further compute the equilibrium profile explicitly for certain special cases, which include the small-match case of two players, and well as the case of Poisson demand.

Yoav Kerner, Eliran Schertzer

Strategic reneging from an M/G/1 queue

We study the strategic behavior of customer in an observable FCFS M/G/1 queue. We assume homogeneous customers, each with linear waiting cost. We focus on service time distribution with Decreasing Failure Rate and assume that while waiting, customers observe the dynamic of the queue continuously, including reneging of customers in front of them. We show that under individual rationality, there is the threshold, such that upon, a customer will join only if the queue length is smaller than this threshold. Also, we show that after joining, there is a pure Nash Equilibrium for the time of staying before reneging, defined also by two sequences of thresholds. We show how to compute these sequences.

Stochastic Optimization - Chair: Israel David

Michael Bendersky, Israel David

Advanced Methods for Artillery Fire Transfer

The present study deals with deriving new algorithms for artillery fire transfer. Fire Transfer implies an immediate artillery engagement of a target ("fire for effect") without a prior fire adjustment (by a forward observer). The capability of fire transfer has obvious and important operational advantages. The Transfer methods, or algorithms, rely on the fire adjustment for another target, an "auxiliary target", or the fire adjustment of several such auxiliary targets.
The innovation of this work is the basic mathematical modeling of artillery fire that takes into account the various determinants of fire accuracy, the adjustment process and the fire transfer. In each of the proposed algorithms we analyze the residual (post-correction and fire transfer) errors at any given plausible target, both in the deterministic sense (where the error factors are known in advance) and in the stochastic case, where the error factors are random variables. If the algorithm is weight dependent, an appropriate optimization problem for the optimal weights is formulated and solved explicitly.
We invoke three different statistical estimation approaches to the firing problem. As a result, the presented fire transfer algorithms differ methodologically and thus should be compared carefully. Each method having its own advantages and disadvantages. The first approach has its point of departure in an existing transfer method, known as "Met+VE" in the US Armed Forces, or the "Notar" (remaining) Correction at the IDF. The main idea behind this method is the embodiment of the observed errors at the auxiliary target in two scalar, physical fire accuracy factors: one for the range error, and the second for the "deflection" (cross-range) error. The second approach assumes *two* auxiliary targets, and it entails no optimization part, as it is assumed that knowledge of *four* error factors is enough to hit a target. The third approach resorts to *Kalman filtering*, assuming a sequential fire adjustment at two or more auxiliary targets.

Adam Shwartz, Segev Wasserkrug, Alexander Zadorojniy, Sergey Zeltyn

Decomposition Algorithms for Constrained Markov Decision Process with an Application to Wastewater Treatment Plants' Optimization

Our work is motivated by the need to optimize the operations of wastewater treatment plants (WWTPs). Many such plants consist of three main parts connected in series, with possible feedbacks between the parts. The sewage (or influent) enters the liquid line part of the plant, which outputs both treated water which must meet regulatory permits, and a more solid mass called sludge. The sludge then goes to the sludge line part of the plant, which treats the solids (sludge) to a level where they can either be used (e.g., as fertilizer), or safely disposed of. The liquids output by the sludge line are recycled back to the input of the liquid line. Another output produced by the sludge line is methane gas, which is passed on to the third part of the plant – the gas line. The gas line either stores the gas, or transforms it to electricity.
One main challenge is to operate the WWTPs in the most cost effective manner, while maintaining regulatory permits regarding the treated wastewater and sludge. In each such plant, there are numerous control options. In addition, the input to the plant (the influent) is highly dynamic with high daily variations, and the processes in the plant are complex biological, physical and chemical processes, usually modelled as a set of first order differential equations.

Finally, while the effect of some control actions may be felt within minutes or hours, the effects of others, especially in the sludge line, may only be felt in a manner of days.
Constrained Markov Decision processes (CMDPs) are an ideal mechanism to model the operational optimization of such plants, as they can both capture the uncertainties inherent in the plant input, and abstract away the operational complexities by using a probability space representation. However, the state and action spaces of the whole plant are enormous (thousands of control actions and billions of states). To deal with this size we developed two algorithms which use a decomposition technique to reduce both the overall state space and the overall action space to several separate state and action spaces, each composed of several thousand and several hundred possibilities, of states and actions respectively. In both algorithms each part of the plant is modeled as a separate CMDP with a different state and action space. Both algorithms also propagate the costs back from the gas line, through the sludge line, and, finally, to the liquid line, in order to take into account, for example, the effects of actions taken by the liquid line on the costs of the sludge line. In addition, both algorithms use specialized constraints in order to take into account the effect the actions may have on the possible feedbacks between the parts. The first algotithm only takes into account the "average" inputs realizations, and, therefore, may not correctly capture the different time scales associated with the different actions, while the second takes into account the distribution of the inputs. While our optimization algorithms have been developed in the context of optimizing WWTPs' operations, we fully expect them to be applicable to a variety of complex control scenarios.

Asaf Levin, Aleksander Vainer

Adaptivity in the stochastic blackjack knapsack problem

We consider a stochastic variant of the NP-hard 0/1 knapsack problem in which item values are deterministic and item sizes are independent random variables with known, arbitrary distributions. Items are placed in the knapsack sequentially, and the act of placing an item in the knapsack instantiates its size. In every stage of insertion if the subset of the items inserted thus far is feasible, then it has a total value that equals to the sum of values of all items of this subset. Otherwise, if the subset violates the constraint, then its value equals to zero. The goal is to compute a policy for insertion of the items, that maximizes the expected total value of items placed in the knapsack.
We consider both nonadaptive policies (that designate a priori a fixed subset of items to insert) and adaptive policies (that can make dynamic decisions based on the instantiated sizes of items placed in the knapsack thus far). Our work characterizes the benefit of adaptivity. For this purpose we use a measure called the adaptivity gap: the supremum over instances of the ratio between the expected value obtained by an optimal adaptive policy and the expected value obtained by an optimal non-adaptive policy. First we show a tight bound of 3/2 on the adaptivity gap for the case of inputs consisting of only two items.

Then we present a non-adaptive policy with expected value that is at least $\left(\sqrt{2}-1\right)^2/2 \approx 1/11.66$ times the expected value of the optimal adaptive policy. Thus the adaptivity gap in this model is at most 11.66 . Additionally this non-adaptive policy is computed in polynomial time. Finally, we consider a special case of the model where all sizes are distributed according to Bernoulli distribution with different parameters. For this special case we improve our result and bound the adaptivity gap by 8.

Michael Bendersky, Israel David

The Full-Information Secretary Problem – New Explicit Results

A decision maker has to choose one from among a Poisson stream of i.i.d. bids, with no recall. The process is subject to a Uniform deterioration (first case) or to an Erlang one (in the second case). We solve the problem explicitly for maximal expected gain, for bids that may take on any finite number of values. A fast procedure to solve the problem numerically for any Fixed horizon problem is presented as well.

Optimization 2 - Chair: Noam Goldberg

Hussein Naseraldin, Opher Baron

Robust Capacity Planning Under Service Constraints

Capacity planning decisions are often strategic in nature thus, are very important. For example, in the healthcare sector, the determination of a facility's capacity must take into account service considerations. Typically, the capacity decision is determined at the beginning of the horizon, which becomes the maximal possible capacity that can be utilized in any single period. In other words, the available capacity in each period is constrained by that initial maximal capacity. Therefore, it is desirable to approach capacity planning in a two-stage nature – design followed by evaluating the resulting performance and service. A major complicating aspect of capacity planning of a facility is data uncertainty. For example, a healthcare clinic may be designed to serve a specific customer arrival rate; but it is

plausible that the arrival rate would change over time. If the system is not designed to cope with such uncertainty, public health might be at risk. Hence, determining capacity in the healthcare sector requires robust solutions under all realizations of the uncertain arrival rate. The aim of this paper is to propose an optimal robust capacity level of service facility, such that service level requirements are maintained at a minimal cost. To cope with the uncertainty in the arrival rate, we adopt the Robust Optimization approach in which one searches for a feasible solution that is at least as good as all other feasible solutions for most data realizations. We search for the optimal capacity level that minimizes the total capacity costs, which include a cost for initiating the maximal capacity and a cost for the selected capacity in each period. We also include in the objective function the service cost, which is defined as the possible cost of not meeting the required service level. The methodology of robust optimization allows either to search for worst-case solution – solutions that are immune to all realizations of the uncertain parameter – or a globalized robust solution – a solution in which one takes into account realizations that don't typically happen but when they happen the impact is huge. We propose analytical results with regard to the relation between the optimal capacity, in case we ignore the uncertainty in the arrival rate (nominal case), and the optimal robust and globalized robust capacities. We show that it is imperative to incorporate uncertainty effects into the decision making process. Moreover, adopting a robust optimization approach has significant impacts on the system performance. We show the circumstances under which these impacts are positive.

Amnon Gonen, Uriel Israeli, Tzahi Avrahami

An Improved Heuristic Algorithm for the Set Covering

The set covering problem is well known as an NP-complete problem. The problem is to cover N sites by allocating minimum number of servers. Each server covers a subset of sites, and all the servers cover all the sites. A common heuristic algorithm that solves the problem is the Greedy type algorithm. In this study we present The Improved Heuristic Algorithm (IHA). The algorithm is looking, at each step, for the most problematic site to be covered and it selects one of the servers that cover it. (In cases of more than one problematic site, the algorithm choose it, randomly). The study includes formulating a random problem generator and comparison analyses between the two algorithms. It looks for cases that the IHA is better versus those cases that Greedy is better. In almost all cases the IHA was better. However, there are families of problems where the IHA was much better and other families that the difference was minor. The study is trying to characterize the families of problem for which, the IHA is much better.

Segev Wasserkrug, Alexander Zadorojniy, Alexey Tsitkin

Relieving Pressure: Optimizing Water Distribution Pressure Management at Valley of the Moon Water District

Efficiently managing pressure in a water distribution network is an issue for water utilities worldwide. It requires utilities to reach and maintain a delicate balance between lowering the pressure as much as possible to reduce water loss and electricity use—two major operational issues costing tens of billions of dollars worldwide—while keeping pressure high enough to maintain the required level of service. Optimizing the pressure in the networks is challenging as it often requires simultaneously controlling multiple types of physical equipment such as valves and pumps, where as a change in the setting of any single piece of equipment could potentially impact the pressure in the entire network. One such utility attempting to improve its pressure management was Valley of the Moon Water District (VOMWD) in Sonoma County, California. The main issue faced by VOMWD was how to adapt the pressure in the network to seasonal changes in water demand by simultaneously controlling ten valves. In this presentation, we will describe how we created an optimization solution for pressure management, and deployed it at VOMWD. Our system incorporates a novel optimization algorithm and problem formulation, which, among other things, efficiently solves a non-convex optimization problem and provides solutions robust to the demand and input pressure changes in the network. In this presentation, we will:

- Provide a brief introduction to pressure management in water networks and discuss the associated challenges and opportunities.
- Describe the VOMWD pressure management problem.
- Detail the optimization algorithm we created to solve the resulting non-linear optimization problem.
- Provide an overview of the implementation of our system to the VOMWD water network, and the resulting benefits. These benefits included a measured reduction of 16% in the number of leaks and bursts as compared to the previous year and 19% as compared to the previous three-year average.

While our optimization solution have been developed in the context of the specific needs of VOMWD, we fully expect it to be applicable to many water utilities wishing to improve their pressure management practices. Moreover, the optimizations algorithms we have developed can also be adapted to a variety of additional optimization use cases in the water domain.

Noam Goldberg, Sven Leyffer

Active Set Method for Second-Order Conic-Constrained Quadratic Programming

We consider the minimization of a quadratic objective subject to second-order cone constraints that generalizes the well-studied bound-constrained quadratic programming (QP) problem.
We propose a new two-phase method: in the first phase a projected-gradient method is used to quickly identify the active set of cones, and in the second phase Newton's method is applied to rapidly converge given the subsystem of active cones. Computational experiments confirm that the conically constrained QP is solved more efficiently by our method than by specialized conic optimization solvers and a general nonlinear programming solver. We further suggest how to generalize the two-phase method to solve problems with additional linear constraints using an augmented Lagrangian approach.

Operations Management 2 - Chair: Dina Smirnov

Simona Cohen-Kadosh, Zilla Sinuany-Stern

The Effect of the Socio-Economic Index on the Efficiency of Orthopedic Wards via Data Envelopment Analysis

In this study we investigate the effect of the socio-economic status of patients on the efficiency of orthopedic wards in 20 acute hospitals in Israel. The efficiency was measured by Data Envelopment Analysis (DEA). DEA is equipped to deal with multiple inputs and outputs, with various units of measurements. It measures the relative efficiency of Decision Making Units (DMUs) based on the ratio between the sums of the weighted outputs and the sum of the weighted inputs. It is a non-parametric model.
The original model CCR was developed by Charnes Cooper and Rhodes (1978). The second version BCC was developed by Banker Charnes and Cooper (1984), which incorporates a constant which accounts for returns to scale. For every DMU, DEA finds the optimal weights which maximize the sum of the weighted outputs given the sum of weighted inputs subject to given bound of 1 on the output input ratio of all DMUs. DMUs that receive the maximal ratio – 1 is considered as efficient, while those that do not achieve the maximal ratio – 1 are in-efficient. The slack variables of the dual problem reveal the improvements needed in each output. Another version – input oriented, similarly, minimize the inputs given the outputs. The slack of its dual problem reveals the improvements needed in the inputs. A third version, called the Additive model allows improvements in both – outputs and inputs. There are more versions of DEA in the literature. However, we are using here only these main versions.
DEA is often used in measuring hospitals' efficiency, world-wide – usually from the viewpoint of the hospitals, based on: number of beds, as inputs, and number hospitalization days, and number of patients as outputs. In this study we concentrate on the efficiency of Israeli acute hospitals from the view of the regulator – the Ministry of Health, which covers many costs and services of hospitals in Israel. In our study, the inputs are: the number of beds and the number of hospitalization days. While the outputs are: the number of patients, and the number of deaths (as undesirable output). An undesirable output was dealt here by various methods. At the second stage, in order to test the effect of the Socio-Economic Index (SEI) of the patients on the hospitals efficiency, we used linear regression. We also used another approach, used in the literature, where SEI is used as environmental input within the DEA. Since DEA is, naturally, dependent on the inputs and outputs chosen, we observed the correlations between the efficiencies of the various versions, for validation.
The data for this study was taken from the Health ministry publications of 2009. Due to some unpublished data included here, we were not allowed to reveal the identity of the various hospitals. The SEI data was taken from the Central Bureau of Statistics of Israel. Our null hypothesis is that SEI is positively correlated with efficiency.

Moshe Kaspi, Moshe Zofi, Ron Teller

Maximizing the Profit per Unit Time for the Travelling Salesman Problem

This paper deals with a new extension of the Travelling Salesman Problem (TSP) in which the objective is to maximize the profit per unit time. A travelling salesman has to complete a tour comprised of n cities. The tour starts and ends at one of the cities and must pass through all n cities. There are several travelling options between every pair of cities which differ in their costs and durations. When completing the tour, the travelling salesman will receive a predefined known income. The salesman's profit per unit time is defined as the profit gained after completing the tour (calculated by subtracting the route's costs from the profit) divided by the total time required to complete the tour.
This problem is a new practical and more complex extension of the well-studied TSP due to the multiple travelling options. The paper defines the problem and presents an iterative solution procedure, which converges after a limited number of iterations, while each iteration having the same time complexity of solving the classical TSP optimally or heuristically.

Eran Hanany, Shulamit Lederman, Michal Tzur

Strategic Lateral Transshipment with Communication Constraints

Usually, an inventory system is composed by multiple local warehouses and one or a few central warehouses. The local warehouses (or retailers) are located close to customers and are used to ensure immediate demand supply to customers. The central warehouse(s) (or supplier) replenishes the local warehouse, but they can also perform an emergency delivery to the customers in case of local warehouse shortage. However, the emergency supply often incurs in higher delivery costs and lower service level. Thus, some alternatives to the hierarchical transportation flow should be analyzed. In this work we study the option of introducing flexibility to the system and allowing stocks movement between locations of the same echelon level. These alternative is called lateral transshipment, or horizontal inventory pooling once members of the same echelon pool their inventories. The pooling allow local warehouses to lower their inventory levels and costs whilst still achieving the required service levels. Several studies have been published over the years which addressed transshipment problems. Different variations of the problem have been analyzed, however most of them considered pre-defined configurations. The present work focuses on transshipment problems with communication constraints, and aims to find the resulting transshipment configuration. LPs are formulated in order to calculate the system optimum with communication constraints and also the system equilibrium. The problem is analyzed as a Potential Game, and we find that the system optimum achieved almost all benefits of the complete pooling system. Finally, an algorithm is presented, which establishes optimal decisions for each retailer based on imperfect information about retailers' inventory realization. The results indicate that, in most of the cases, the transshipment of units between retailers through a unidirectional chain configuration is an optimal network. In addition, in the optimal configuration, no split is applied, generally, for shortage or surplus inventory realizations.

Dina Smirnov, Yale T. Herer

The Two-Phase Distribution Problem

Due to the recent advances in Information Technology, previously unavailable information regarding inventories at different entities in the supply chain has become available to the decision makers, thus enabling faster and more exact reactions to demand fluctuations. In particular, it has become possible to review the inventory levels in the system more than once in a period. Our study addresses an inventory system of multiple independent retailers with a common supplier, who has a single production or purchase opportunity per period, before the beginning of the period. We apply partial aggregation of inventories aimed at implementing the risk pooling principle. Each period is divided into two sub-periods. Part of the available inventory is distributed to the retailers at the beginning of the first sub-period, while the rest is held undelivered to distribute at the beginning of the second sub-period. We aim to determine the optimal production quantity, as well as the quantity distributed to each retailer in each sub-period. Unlike previous studies, here the optimality conditions are obtained analytically, and various insights on the effect of problem parameters on the decision variables are provided. In addition, we show that if certain conditions are satisfied, then the solution to the problem is straightforward.

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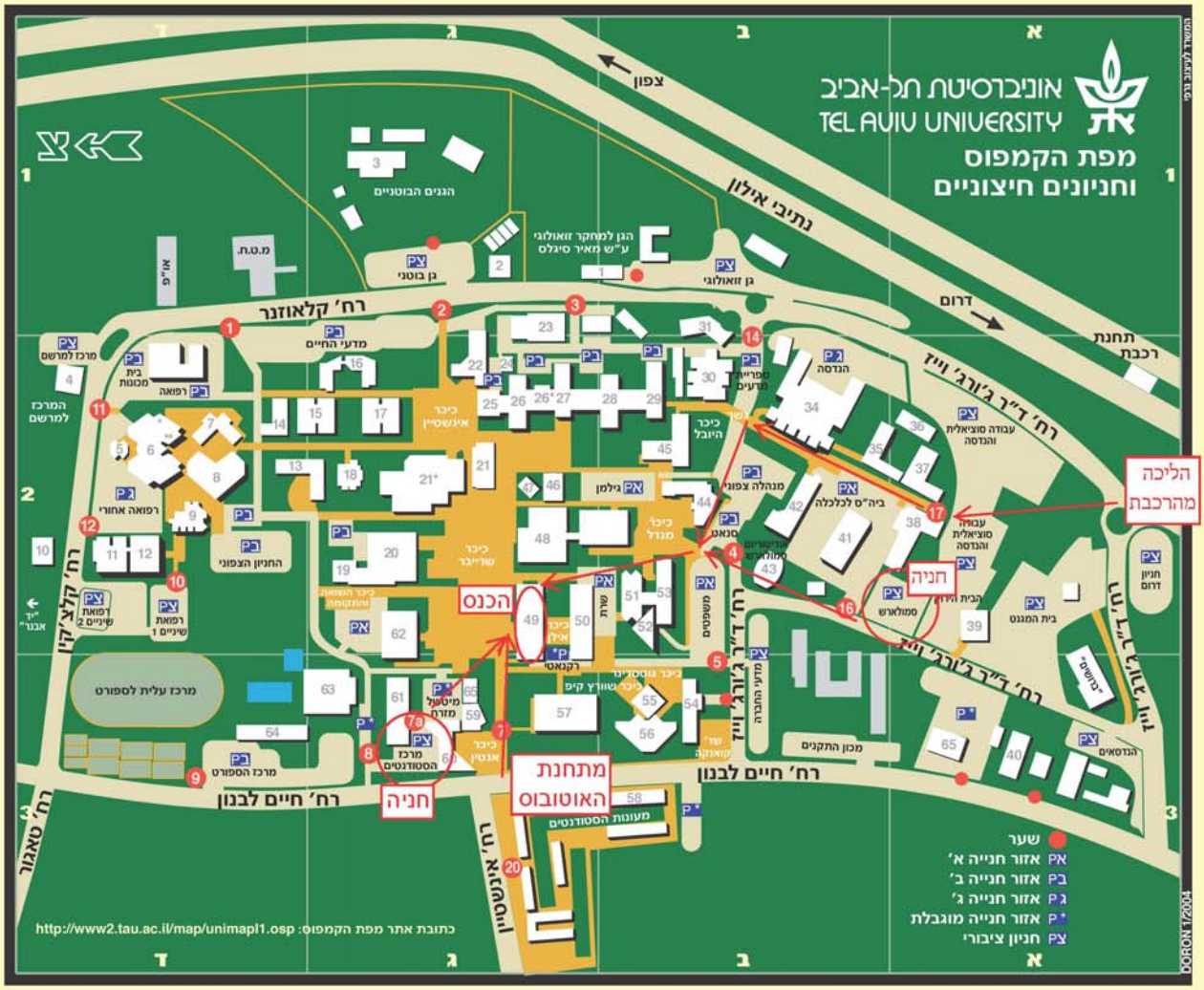
הגעה לכנס



תמצית מפת האוניברסיטה על־פי תחומי מחקר, הוראה ומינהל

אודיטוריום	55 ,43 ,7	מינהלה	44 ,42 ,24
אמנויות	62 ,59 ,57	מרכז החישובים	25
בית הספר לאדריכלות	61	משפטים	53 ,52 ,51
בית התפוצות – מוזאון	*21	מדעים מדויקים	31 ,30 ,26 ,25 ,22
גנים בוטניים	3	ניהול	56 ,49
דיונון (אופיס דיפו)	60	ספורט	64 ,63
גן זואולוגי	1	ספריות	56 ,51 ,30 ,20 ,19 ,8
בית הספר להנדסאים	40	פיזיקה	31 ,30 ,27 ,26
הנדסה	37 ,36 ,35 ,34 ,30, 31	עבודה סוציאלית	38
חברה	56 ,54 ,41	רוח	48 ,20 ,13 ,10
חינוך	50	מרכז למרשם	4
יהדות	46 ,21 ,*21 ,18, 19	רפואה	14 ,9 ,8 ,6 ,5
כימיה	31 ,30 ,29 ,28	רפואת־שיניים	12 ,11 ,8
מדעי החיים	17 ,16 ,15 ,14 ,8 ,3 ,2 ,1	דקאן הסטודנטים	60
מועדוני האוניברסיטה	13 ,39	אגף הנדסה ותחזוקה	24 ,23
מכון למחקרי ביטחון	65	שפות	48 ,13

שערים לכלי רכב

1. שער אוסטריה (ד–1)
4. שער רמניסיאנו (ב–2)
8. שער דן בוכנר (ג–3)
14. שער "לימודי חוץ" (ב–2)
18. שער "עבודה סוציאלית" (ב–2)

שערים להולכי־רגל

2. שער מתתיה (ג–1)
5. שער יוסף קריס (ב–3)
7. שער פרנקל (ג–3)
9. שער יוסף סאפר (ד–3)
10. שער "רפואת שיניים" (ד–2)
17. שער "כיתות חשמל" (א–2)
20. שער "מעונות" (ג–3)

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