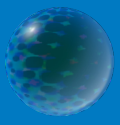
SCoDO I

First TUM Students´ Conference on Discrete Optimization and Final Meeting for the TUM Felix-Klein Lecture 2009

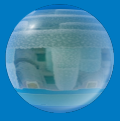
Date: **Saturday, 25th of July 2009, 8:45 - 18:00**
Venue: **HS 0606 (TUM Stammgelände)**

Themes and Speakers:

Combinatorial Auctions: **Anja Hoppenkamps, Remy Lazarovici, Alexander Schembera, Nihad Shalaby, Daniel Silvestrini, Alexander Zschiesche**

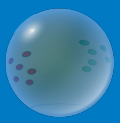


Digital Halftoning: **Thomas Bredl, Daniela Fußeder, Erik Johansson, Lisa Kehrer, Katharina Wohlgemuth**



Semiconductor Design: **Pirmin Fontaine, Elena Gräfenstein, Andreas Kirsch, Christina Maier, Daniel Opritescu, Nicole Wochatz**

Energy Storage: **Barnabas Arvay, Dominik Billing, Alexander Breuer, Thomas Fischer, Lisa Henkel, Thomas Himmelstoß**



Cluster Analysis: **Susanne Ellßel, Larissa Hammerstein, Philipp Hupp, Andreas Schrottenloher, Vivien Tröbs, Martin Zach**

Logistics: **Jasmin Benz, Sebastian Cid Gomez, Conrad Donau, Marc Hoffmann, Michael Pachali**

Recent Advances in Mixed Integer Programming: **Oliver Bastert (FICO)**

Program

Session 1 – Mathematical Talks (chair: Michael Ritter)

8:45	–	9:00	The Organizers **Welcome**
9:00	–	9:30	Team "Combinatorial Auctions" *Anja Hoppenkamps, Remy Lazarovici, Alexander Schembera, Nihad Shalaby, Daniel Silvestrini, Alexander Zschiesche* **Combinatorial Auctions and the Winner Determination Problem**
9:30	–	10:00	Team "Digital Halftoning" *Thomas Bredl, Daniela Fußeder, Erik Johansson, Lisa Kehrer, Katharina Wohlgemuth* **Optimization Methods in Digital Halftoning**
10:00	–	10:30	Team "Semiconductor Design" *Pirmin Fontaine, Elena Gräfenstein, Andreas Kirsch, Christina Maier, Daniel Opritescu, Nicole Wochatz* **Cradle of Technology — Semiconductor Optimization**
10:30	–	11:00	Coffee Break

Session 2 – Mathematical Talks (chair: Barbara Wilhelm)

11:00	–	11:30	Team "Energy Storage" *Barnabas Arvay, Dominik Billing, Alexander Breuer, Thomas Fischer, Lisa Henkel, Thomas Himmelstoß* **We've got the power!**
11:30	–	12:00	Team "Cluster Analysis" *Susanne Ellßel, Larissa Hammerstein, Philipp Hupp, Andreas Schrottenloher, Vivien Tröbs, Martin Zach* **Cluster analysis: Comparison of K-Means and DBSCAN**
12:00	–	12:30	Team "Logistics" *Jasmin Benz, Sebastian Cid Gomez, Conrad Donau, Marc Hoffmann, Michael Pachali* **Vehicle Scheduling in Logistics — Using the Example of "Telebus Berlin"**
12:30	–	14:00	Lunch Break

Session 3: Presentation Talks (chair: Markus Brill)

14:00	–	14:15	Team "Combinatorial Auctions" *Anja Hoppenkamps, Remy Lazarovici, Alexander Schembera, Nihad Shalaby, Daniel Silvestrini, Alexander Zschiesche* **Combinatorial Auctions and the Winner Determination Problem**
14:15	–	14:30	Team "Semiconductor Design" *Pirmin Fontaine, Elena Gräfenstein, Andreas Kirsch, Christina Maier, Daniel Opritescu, Nicole Wochatz* **Cradle of Technology — Semiconductor Optimization**
14:30	–	14:45	Team "Energy Storage" *Barnabas Arvay, Dominik Billing, Aexander Breuer, Thomas Fischer, Lisa Henkel, Thomas Himmelstoß* **We've got the power!**

Session 4: Invited Talks (chair: Oliver Bastert)

14:45	–	15:30	Petra Bauer, Siemens AG **Optimization for SIPLACE Placement Systems**
15:30	–	16:00	Coffee Break

Session 5: Presentation Talks (chair: René Brandenberg)

16:00	–	16:45	Oliver Bastert, FICO **Recent Advances in Mixed Integer Programming**
16:45	–	17:00	Team "Digital Halftoning" *Thomas Bredl, Daniela Fußeder, Erik Johansson, Lisa Kehrer, Katharina Wohlgemuth* **Is my Printer a Maths Genius?**
17:00	–	17:15	Team "Cluster Analysis" *Susanne Ellßel, Larissa Hammerstein, Philipp Hupp, Andreas Schrottenloher, Vivien Tröbs, Martin Zach* **An interactive approach to cluster analysis**
17:15	–	17:30	Team "Logistics" *Jasmin Benz, Sebastian Cid Gomez, Conrad Donau, Marc Hoffmann, Michael Pachali* **Vehicle Scheduling in Logistics — Using the Example of "Telebus Berlin"**

Session 6: Evaluation and Certificates (chair: Barbara Langfeld)

17:30	–	18:00	**Evaluation and Discussion**
18:00	–	18:30	Barbara Langfeld, Michael Ritter, Barbara Wilhelm **Certificates**

Conference Dinner

18:30	Conference Dinner

Abstracts

Combinatorial Auctions and the Winner Determination Problem

Team "Combinatorial Auctions"
Anja Hoppenkamps, Remy Lazarovici, Alexander Schembera, Nihad Shalaby, Daniel Silvestrini, Alexander Zschiesche

An auction is a process of buying and selling goods by taking bids and selling the item to the highest bidder. Auction houses for example sell items for which no fair market value exists, such as for paintings or antiques. But there are also a lot of auctions which involve a variety of distinct assets. Because of complementary or substitution effects between the different assets, bidders have preferences not just for single objects but for bundles of objects. For this reason, economic efficiency is increased if bidders can also bid on bundles or combinations of different items. Auctions where bidders submit bids on combinations have recently received much attention, such as the sale of the British 3G Telecom licenses.

These so called combinatorial auctions lead the auctioneer to various questions: On which bundles should bidders be able to bid? How do bidders communicate their bids to the auctioneer? How does the auctioneer select the winning bids?

The last question ist also known as the Combinatorial Auction Problem (CAP) or the Winner Determination Problem. In our talk we would like to focus on that problem and formulate it as a linear program. We will use an example to illustrate a possible solution of such a problem by using linear optimization.

Optimization Methods in Digital Halftoning

Team "Digital Halftoning"
Thomas Bredl, Daniela Fußeder, Erik Johansson, Lisa Kehrer, Katharina Wohlgemuth

Printers are common household devices today. But although we can create high gloss photos at home, printing grey halftone areas is still a challenging optimization problem. In a greyscale printout one may notice some patterns, so called textures. They occur when converting the continuous image to a binary output and are, of course, unwanted. Although there already exist mathematical approaches to preventing such patterns, technical restrictions of laser printers interfere with these methods: Printer requirements counteract visually acceptable printing results. Furthermore one single method is required to work well for all shades of grey simultaneously. It is not known if there exists an optimal solution at all. But here an approach to solving the problem through discrete optimization is given. The best results are achieved through the maximization of distances of the printed dots within the technical restraints. With this ansatz we can present a high average of satisfying results for greyscales. In addition we show several mathematical quality criteria to enable a more scientific comparison of methods, which is no longer based on visual perception.

Cradle of Technology — Semiconductor Optimization

Team “Semiconductor Design”
Pirmin Fontaine, Elena Gräfenstein, Andreas Kirsch, Christina Maier, Daniel Opritescu, Nicole Wochatz

These days almost every electronic device contains semiconductor chips. In order to keep the energy consumption low, for example to improve battery running times, it is essential to design and produce chips with minimal energy loss. Semiconductor circuits consist of many parallel wires. The main problem is that between these wires electromagnetic fields are generated whenever the voltage on one of the wires changes. These fields cause thermal energy loss that needs to be reduced.

This task can be tackled by finding on the one hand an optimal ordering and on the other hand an optimal spacing of the wires. Before developing the mathematical optimization problem a physical model of the system has to be created. After that the physical values have to be interpreted as mathematical variables and parameters and the OPTIMAL WIRE PLACEMENT PROBLEM, consisting of OPTIMAL WIRE ORDERING and OPTIMAL WIRE SPACING, has to be shaped with all of its constraints.

For each subproblem solutions can be computed and algorithms can be implemented. Finally the results can be merged and so a solution for the OPTIMAL WIRE PLACEMENT is found. Exploiting these results in the design of semiconductor circuits can reduce thermal energy loss by more than 5%.

We’ve got the power!

Team “Energy Storage”
Barnabas Arvay, Dominik Billing, Alexander Breuer, Thomas Fischer, Lisa Henkel, Thomas Himmelstoß

Germany will shut down all nuclear power facilities until 2021. Instead 30% of the German energy requirement shall be covered by renewable energy like water, wind or solar power. As a matter of fact these new energy sources are not reliable and predictable. It becomes more and more important to develop new power storing technology and to use the existing facilities as efficiently as possible. For the problem of optimal usage of power storing facilities we developed in our project work a mathematical model and program which relies on given generation plants and network loads in Germany. Besides we created a website on which we present the given problem and our results in an illustrative way to make the information understandable even for people without any mathematical background knowledge.

Cluster analysis: Comparison of K-Means and DBSCAN

Team "Cluster Analysis"
Susanne Ellßel, Larissa Hammerstein, Philipp Hupp, Andreas Schrottenloher, Vivien Tröbs, Martin Zach

Clustering techniques deal with the issue of dividing data points into sets which contain similar points. In this talk we will address two special cluster algorithms, K-Means and DBSCAN. K-Means divides the data points into K clusters by iteratively assigning the data points to the nearest cluster center and recomputing the centers of the clusters. In contrast, DBSCAN is a density-based approach to the topic. The algorithm recognizes areas of high density as clusters whereas two clusters are separated by an area of low density. We will introduce these algorithms, discuss their advantages and disadvantages and compare them to each other. Examples will be used to illustrate the differences. Furthermore, we will introduce outliers, data points which are somewhat isolated, talk about outlier detection and about how to manipulate the data set so that the algorithms we are discussing obtain better results.

Vehicle Scheduling in Logistics — Using the Example of "Telebus Berlin"

Team "Logistics"
Jasmin Benz, Sebastian Cid Gomez, Conrad Donau, Marc Hoffmann, Michael Pachali

Mathematical optimization of transport problems presents a range of constraints that must be met. In real world applications such as Berlin's Telebus for handicapped people, strategic as well as operational planning, decisions in space and time, complicated feasibility constraints and multiple objectives constitute some relevant aspects.

The generic problem considered is a Dial-a-Ride-Problem, in which vehicle schedules are to be determined by transportation requests. The goal is to obtain a set of vehicle schedules that minimize the volume of subcontracted transport services.

A two-step approach is used to decompose the problem into a clustering and a chaining step. Both can be modeled as set partitioning problems. The clustering step combines requests to clusters under "local" constraints, and the chaining step links these together to vehicle tours considering "global" constraints.

Using branch-and-cut methods, we obtain a set of best clusterings from the clustering step. The chaining step additionally involves heuristics to reduce the volume of possible combinations, leading to good but not necessarily optimal vehicle tours that meet the constraints provided.

The use of mathematical models for planning vehicle schedules at Telebus has kept costs at a steady level for a 30% increase in service requests.

Optimization for SIPLACE Placement Systems

Petra Bauer
Siemens AG, Coporate Technology

The challenges we are facing in the context of printed circuit board assembly range from optimizing the line performance for a given job to optimizing the overall production process by finding appropriate manufacturing and set-up strategies and providing algorithms in order to support them.

We introduce the SIPLACE machines and give insight into manufacturing concepts and setup-strategies as well as the optimization problems we have been working on.

In particular, we consider the concept of "constant tables", a setup-strategy that helps our customers, especially those having to cope with a high mix / low volume environment, to save setup-times and feeder equipment.

Recent Advances in Mixed Integer Programming

Oliver Bastert
FICO

Mixed integer programs are best solved using so-called branch and cut algorithms. Typically preprocessing is applied to the mixed integer program first, i. e. trying to reformulate the problem to make it easier to solve. Then the linear relaxation of the problem is solved. Afterwards cutting planes are added to the problem and heuristics are applied to find good feasible solutions. In preferable cases this suffices to solve the problem to optimality.

If this is not the case, the problem is divided (branching) into smaller subproblems which are solved individually. This constitutes the branch and bound tree. To each of the subproblems the same techniques are applied as to the original problem.

We will discuss latest developments and open problems regarding the key aspects of solving mixed integer programs.

The main focus will be on

- Heuristics — Feasibility pump, local branching and beyond
  Finding good solutions quickly is a major requirement. During the last couple of years we have seen lots of activity around mixed integer programming based local search heuristics.
- Branching
  Besides cutting planes, good and fast branching is the key to proving optimality.
  - Keeping the size of the branch and bound tree small — strong(er) branching

  - Spending little time on branching decisions — using historic branching information
  - More interesting ways of branching than just $\{x \in P : x = 1\} \dot{\vee} \{x \in P : x = 0\}$ for fractional x

- Parallelism
  Due to the general availability of multicore/multi cpu systems this topic is of great interest these days.
  - What can be done in parallel when solving mixed integer programs?
  - Parallelism and determinism

Venue

Conference: HS 0606, TU München, Stammgelände

Entrance through main entrance (“Pforte”) only!