

Summary Future Perspectives Closing CO@W Berlin

Martin Grötschel

9. 10. 2009

11:30 – 13:00

Martin Grötschel

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- DFG-Forschungszentrum „Mathematik für Schlüsseltechnologien“ (MATHEON)
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Today's program

CO@W

Fr 09.10.

Finish

09:00-10:00 TK

Real world data again

10:00-11:00 MG

Results of examination

11:30-13:00 MG

Summary, future perspectives and closing



Contents

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3. What happens internationally?
 - IMU - International Mathematical Union (CDC, ICMI, CEIC)
 - Formation of centers
4. Questions, remarks, critique?
5. Thanks



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What have we done?

Mathematical problems touched

- Linear and mixed integer programming
- Constraint Programming
- Polyhedral theory
- Polyhedral combinatorics (facets, cutting planes, etc.)
- Nonlinear integer programming
- Complexity theory
- Online optimization
- Worst case analysis
- Auction theory



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What have we done?

Mathematical algorithms/software touched

- Linear and mixed integer programming
 - Solving LPs and MIPs in practice
 - Dual and primal simplex, interior point methods
 - CPLEX in ~1200 cities
 - Branch and Bound
 - Cutting planes
 - Presolving
- Constraint Programming
- Nonlinear integer programming
- Online optimization
- Special combinatorial optimization problems
 - Various flow problems
 - Shortest paths with additional restrictions
 - TSP and variants
 - etc.



What have we done? Software

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Academic Software

- Zimpl
- Soplex
- SCIP
- PORTA
- Polymake
- COIN-OR

Commercial Software

- CPLEX
- Gurobi
- XPRESS
- MOSEK
- etc.

Some participants complained that there was too much programming and software usage training.

Well, if you want to solve real-world problems there is no way around that.

I do hope that you have learned to employ the tools that were presented and test the academic and commercial software made available to you.

Tu 29.09.		(Commercial) Solvers: state-of-the-art
09:00-09:15	HM	Introduction
09:15-10:00	BB	Gurobi
10:00-10:45	TA	CPLEX
11:15-12:00	OB	Xpress
12:00-12:45	EA	MOSEK and Interior Point
14:15-15:00	TR	COIN-OR
15:30-16:15	EA	Conic Quadratic Optimization
16:30-17:30	MH	Integer Programming at Siemens



What have we done?

Software

- Don't forget: software needs data (Thorsten Koch)
- Don't forget: software needs testing and comparisons (Hans Mittelmann)

```

8 Oct 2009  =====
Feasibility Benchmark - Feaspump, CPLEX, SCIP, GUROBI
=====
H. Mittelmann (mittelmann@asu.edu)

```

Logfiles for these runs are at http://plato.asu.edu/ftp/feas_bench_logs/

MILP problems from the following sources were solved for a feasible point

<http://miplib.zib.de/>
<http://coral.ie.lehigh.edu/mip-instances/>
<http://plato.asu.edu/ftp/milp/>
<http://plato.asu.edu/ftp/unibo/>
http://plato.asu.edu/ftp/fp_sub/

The following codes were run on one CPU of a 2.67GHz Intel Core2 under Linux:

CPLEX-12.1: <http://www.ilog.com/cplex/> (single thread)
 FEASPUMP: http://www.or.deis.unibo.it/research_pages/ORcodes/FP-gen.html
 "ab"/"bfl": Achterberg-Berthold/Bertacco-Fischetti-Lodi variants
 as implemented for interactive use at NEOS: <http://neos.mcs.anl.gov/> (utilizes CPLEX)
 SCIP-1.2: <http://scip.zib.de/> (uses CPLEX for LP)
 GUROBI-2.0.0: <http://gurobi.com/> (single thread)

Times given are user times in seconds. A time limit of 2 hrs was imposed.

problem	CPLEX	FP-ab	FP-bfl	SCIP	GUROBI
atlanta-ip	848	23	21	213	28
core4872-1529	1	413	52	44	1
ds	1	-	5350	24	2
germanrr	183	10	6	176	19

Test run of

CPLEX, SCIP, GUROBI

yesterday



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Modellierung: What is that?



„Art is a lie that makes us realize truth“



Olga Koklowa

Picasso's first wife

The model of the
mathematician

The model of the artist

A mathematical model is a lie that helps us see the truth.

Picasso and his women: Abstraction



Olga



Francesca



Marie-Thérèse



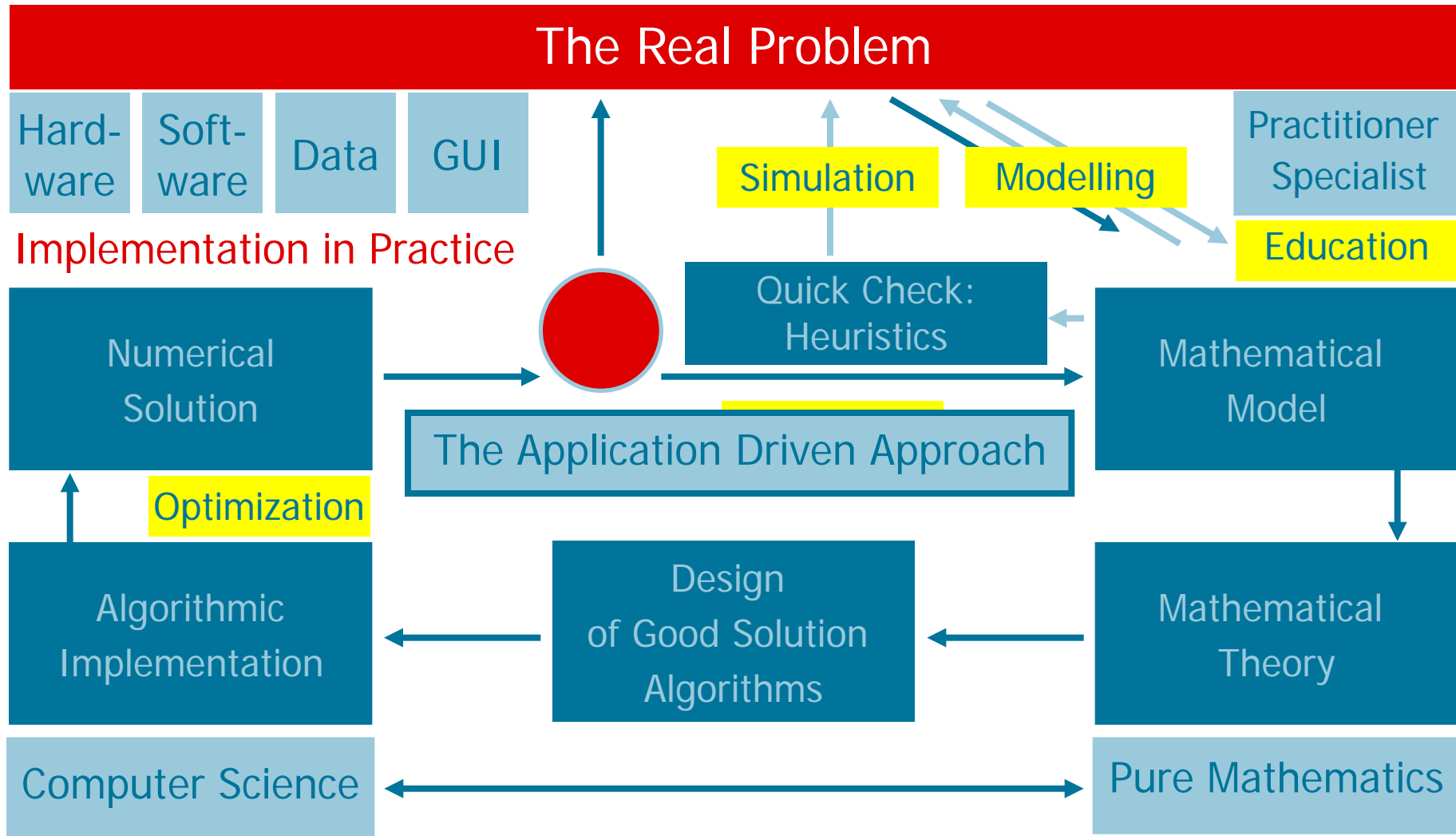
Jacqueline

Which is the most valuable picture?



Francoise

The problem solving cycle in modern applied mathematics



Modeling

- Modeling is an art or craft but unfortunately not a science.
- Modeling is experience based.
- There is no “modeling theory”.



Mathematical models treated

- travelling salesman problem (the prototype problem)
- routing
- location
- set-packing, -partitioning, -covering
- cut problems (max and min)
- scheduling
- node and edge colouring
- shortest paths with resource constraints
- various flow problems
- general IPs and MIPs
- etc.



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What have we done?

Applications

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- Real auctions (single items, combinatorial: real life)
- Control of CNC machines, stacker cranes
- Logistics
- Transportation
- School bussing
- Track allocation
- Public transport
- Vehicle & elevator scheduling
- Telecommunication
- Mining
- Health care
- Gas transport
- ADAC yellow angels
- Open pit mining

Combinatorial Optimization at Work



What have we done?

Applications

- Printed Circuit Board Production
- Wafer Fab (ILOG, Bixby), the semiconductor supply chain
- Real-time dispatching of concrete trucks
- Beef disaggregation
- Supply chain scheduling
- Unit commitment in the electric power industry
- Water Supply Network Planning
- Luggage transport at airports
- Placement machines
- Stacker cranes, elevators, AGVs and the like
- Greeting cards commissioning and assembly lines
- Harbour optimization
- Delivery
- Yellow angels



What have we done?

Applications

- Line planning in public transport
- Crew Scheduling Models
 - Freight Train Scheduling
 - Duty Scheduling in Public Transit
 - Airline Crew Scheduling
 - Telebus
- Online Dial-a-Ride Problems
 - Dispatching the service vehicles of ADAC
 - Controlling cargo elevators in a distribution center
 - Controlling passenger elevators in high-rise buildings
- Integrated Coordination of School Starting Times and Public Transport



What have we done?

Applications

CO@W

- Single Depot Vehicle Scheduling
- Multiple Depot Vehicle Scheduling
- Integrated Vehicle and Duty Scheduling
- Trip Scheduling

- Railway Track Allocation
- Stacker cranes, elevators, AGVs and the like
- Greeting cards commissioning and assembly lines
- Harbour optimization

- Sheet Metal Design
- Recovered Paper Production
- Free Flight Airplane Routes



Telecommunication

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- GSM Frequency/Channel Assignment
- Optimizing the UMTS Radio Interface
- Locating the Nodes of a Network Optimally
- Clustering Base Transceiver Stations
- Balancing the Load of Signaling Transfer Points
- Integrated Topology, Capacity, and Routing Optimization as well as Survivability Planning
- Planning IP Networks
- Optical Network Design
- Traffic Engineering



Telecommunication: mentioned in passing

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- **Designing mobile phones**
 - Task partitioning
 - Chip design (VLSI)
 - Component design
- **Producing Mobile Phones**
 - Production facility layout
 - Control of CNC machines
 - Control of robots
 - Cutting and welding
 - Printed Circuit Boards
 - Via minimization
 - Component Placement
 - Mounting Devices
 - Routing
 - Lot sizing
 - Scheduling
 - Logistics
- **Marketing and Distributing Mobiles**



Health Care (Martin Puterman)

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- Surgeon Scheduling
- Priority Scheduling
- Radiotherapy or Chemotherapy Scheduling
- Workforce Planning
- Facility Location
- Radiotherapy Beam Direction Optimization
- Shift Scheduling
- Surgical Path Control



What have we done?

Data

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- Data game



What have we done?

Visiting companies, entrepreneurship

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- Siemens
- Schering
- HHLA
- ViP

Combinatorial Optimization at Work

- Founding a company
- CPLEX/Gurobi



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Possible research directions

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- Combinations of the following aspects
 - linear
 - mixed-integer
 - nonlinear
 - stochastic
- Multiobjective optimization theory (realistic approaches)
- Theory of online and real time optimization
- Better understanding of semi-algebraic geometry
- Further progress on many special models using the whole available machinery (example: symmetric TSP)



Possible research directions

- Understanding heuristics
 - worst-case behavior
 - average-case behavior (realistic stochastic models)
 - predicting the practical quality of a heuristic
 - (usable) polynomial time approximation schemes
- Stochastic analysis of models
- Hirsch conjecture ?
- $P=NP$?



Possible research directions

CO@W

- Mathematical auction theory,
mechanism design
algorithmic economics
- Mathematics of regulation and deregulation



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Software research and development

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- More use of NLP-techniques in LP and IP (bundle method)
- Stochastic programming codes
- Global optimization codes
- Multiobjective optimization codes
- Research in linear programming
 - almost no progress since 2004
 - simplex
 - interior point methods
- Integration of techniques (CP and MIP, Tobias Achterberg)
- Large scale
- Parallelization



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New applications

- I simply see no end.
- Wherever you look, optimization is needed; and discrete optimization is becoming more and more important since most decisions made are discrete.
- Whether you want to
 - maximize profit
 - minimize cost
 - make best use of resourcesoptimization is required.



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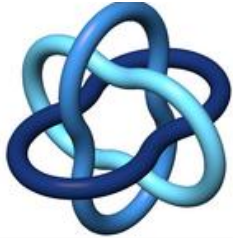
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International Mathematical Union

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International Mathematical Union (IMU)

www.mathunion.org > Home

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General

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Publications

- ▶ **Circular Letters to Adhering Organizations**
- ▶ **Bulletins**
- ▶ **IMU-Net: Electronic Newsletter**
- ▶ **Reports and Recommendations**
- ▶ **News**

Members

- ▶ **Member Countries**
- ▶ **Associate Members**
- ▶ **Affiliate Members**
- ▶ **Candidacy for Membership**

Activities

- ▶ **International Congress of Mathematicians (ICM)**
- ▶ **ICM related and other Grants**
- ▶ **Developing Countries (CDE, DCSG, CDC)**
- ▶ **Mathematical Instruction (ICMI)**
- ▶ **Electronic Information and Communication (CEIC)**

Organization

- ▶ **Executive Committee**
- ▶ **General Assembly**
- ▶ **Statutes**
- ▶ **Committees / Commissions**

Further Info

- ▶ **Mathematical Societies**
- ▶ **Links to the Mathematical World**
- ▶ **Federated World Directory of Mathematicians (FWDM)**

last updated: 2009-09-23

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[IMU Awards and Prizes](#)

[ICM 2010](#)



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International Commission on Mathematical Instruction (of IMU)

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08.30.09

Extended Deadline for Contributions to the ICMI/ICIAM Study

The International Programme Committee of the joint ICMI/ICIAM Study (ICMI Study 20) on *Educational Interfaces between Mathematics and Industry (EIMI)* announces that the deadline for submitting contributions to the Study has been extended from September 15 until OCTOBER 15, 2009.


Instructions on submission of contributions and general information on the Study, organised jointly by the International Commission on Mathematical Instruction (ICMI) and the International Council for Industrial and Applied Mathematics (ICIAM), can be found on the [Study website](#).

The EIMI Study Conference will be held in Lisbon on April 19-23, 2010.



Committee on Electronic Information and Communication (CEIC)

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Committee on Electronic Information and Communication (CEIC)

International Mathematical Union | IMU on the Web | WDML | EWDM | FWDM | Contact

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CEIC Announcements

Spanish Digitization Project

The **Spanish Digital Mathematics Library** is ready to expand to Latin America, June 2007.

Presentation to the General Assembly in Santiago, August 19, 2006

Read the **PDF presentation** made to the IMU describing the CEIC's activities from 2003-2006.

Recommendations on Digital Mathematics Library

With the ultimate goal of creating an enduring network of digital mathematical literature", the General Assembly of the International Mathematical Union on August 20, 2006 at its meeting at Santiago de Compostela formally endorsed the CEIC statement **Digital Mathematical Library: a vision for the Future** and adopted the CEIC recommendation **Some Best Practices for Retrodigitisation**.

[Recommendations on Information and Communication](#)

[Citation Statistics](#)

[Open Access](#) Berlin Declaration



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Formation of Centers

- MATHEON and BMS in Berlin



- Hausdorff Center in Bonn

hausdorff center for mathematics

- MITACS in Canada



- MASCOS in Australia



Collaborative research is getting of increasing importance.

Big questions need big effort.

- CMM in Santiago de Chile



- ICM in Poland



interdyscyplinarne centrum
modelowania matematycznego
i komputerowego



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Questions

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- Your evaluation



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Thanks to all lecturers, helpers,...

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TK	Thorsten Koch	TS	Thomas Schlechte	BE	Berkan Erol
CR	Christan Raack	BH	Benjamin Hiller	MR	Markus Reuter
AW	Axel Werner	AF	Armin Fügenschuh	OH	Olga Heismann
TB	Timo Berthold	MN	Marika Neumann	ID	Ivan Dovica
KW	Kati Wolter	CC	Carlos Cardonha	RD	Rene Dammer
SH	Stefan Heinz	AE	Andreas Eisenblätter	ES	Elmar Swarat
RB	Ralf Borndörfer	MM	Maren Martens	RM	Robert Meirich
DH	Dung Hoang	TO	Thorsten Klug	NP	Nils Paetsch
BB	Bob Bixby	TUGS	Gründungsservice	UK	Urs Kramer
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YB	Yao Ban	NW	Nadia Wisniewski	GG	Gerald Gamrath
AB	Andreas Bley	SV	Stefan Vigerske	RW	Robert Waniek
AG	Ambros Gleixner	IPG	TB,KW,SH,AG,TK	MW	Michael Winkler
HM	Hans Mittelmann	PTG	RB,MN,TS,CC, ID	WH	Wie Huang
TA	Tobias Achterberg	HPC	Hinnerk Stüben&Co	JS	Jonas Schweiger
OB	Oliver Bastert	VIS	Olaf Paetsch	SI	Siarhei Makarevich
EA	Erling Anderson			SM	Sybille Mattrisch
TR	Ted Ralphs			UP	Uwe Pöhle
MH	Michael Hofmeister			BK	Bettina Kasse

and participants

WD	Wolfgang Dalitz
SR	Susanne Richter
WN	Winfried Neun
JL	Jian Li
MH	Mathias Hecht
AVG	WD,SR,WN



Closing

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Summary, Future Perspectives, Closing

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The End

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