

Welcome to Combinatorial Optimization at Work

briefly from now on: **CO@W Berlin**

Martin Grötschel

September 21, 2009

9:15 – 10:30

Martin Grötschel

- Institut für Mathematik, Technische Universität Berlin (TUB)
- DFG-Forschungszentrum “Mathematik für Schlüsseltechnologien” (MATHEON)
- Konrad-Zuse-Zentrum für Informationstechnik Berlin (ZIB)

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<http://www.zib.de/groetschel>



Contents

co@w

1. Program of the Course
2. Participants
3. Berlin
4. TUB, ZIB, MATHEON, BMS
5. The Problem Solving Cycle



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Video Recording

- We intend to record all lectures on video.
- After postprocessing, the videos will be made freely available in the Internet so that the participants, and in particular those who could not come, can watch (or re-use) the lectures.
- If anyone in this room does not agree to be videotaped we should discuss how to settle this now.
- Who does not want to appear on such a videotape?
- The video team: WD Wolfgang Dalitz
SR Susanne Richter
MH Mathias Hecht



CO@Work: Today's Program

Monday, Sept. 21, 2009

08:30-09:15 Registration

09:15-10:30 MG Welcome

Break

11:00-12:30 MG Linear and integer programming: an
introduction

Lunch at FU Mensa

14:00-15:30 MG Basics of polyhedral theory, flows and
networks

Break

16:00-17:30 MG The Travelling Salesman Problem and its
applications



Today's Program

- Today is a warm-up. We focus on a rehearsal of theory.
- We assume that you are familiar with most of the topics to be presented.
- Of course, you will not know all aspects, but you should know the basic facts – otherwise it will be hard to follow.
- A lot of things told briefly and quickly today will be repeated in much more detail in lectures to come.
- This concerns in particular algorithmic aspects of linear and integer programming.



This Week's Program

- Tuesday is **software day**:
Introduction to the ZIB Optimization Suite
- Wednesday is **auction day**:
We will introduce you to auction theory and some of the combinatorial aspects of it. We will execute real auctions! Every participant will get a certain amount of virtual money (the ZIB Mark, briefly ZM), and can use it to buy real objects in various auctions throughout the day. This way you will learn, first hand, the subtleties of auctioning.
- Thursday and Friday are the **Bob Bixby days**: You will hear from one of the mathematical and commercial pioneers (founder of CPLEX) how linear and mixed integer programming problems are solved today in practice.
- Saturday is **SCIP day**: You will learn how to work with SCIP efficiently in practice.



CO@Work: Further Program

see [printed program](#)

Note: Depending on
the development of the course,
requests from participants,
new ideas of the lecturers,
etc.,
there may be program changes.



Special Guests

co@w

- BB Bob Bixby, Gurobi, and Rice University, Houston,
(formerly Cplex and ILOG), **Sept 24-25, 28**
 - HM Hans Mittelmann, Arizona State U
 - TA Tobias Achterberg ILOG/IBM
 - OB Oliver Bastert, FICO (formely Dash)
 - EA Erling Anderson, MOSEK
 - TR Ted Ralphs, Lehigh University, Bethlehem
 - MH Michael Hofmeister, Siemens, München
- } **Sept 29**
-
- MP Martin Puterman, U of British Columbia, Vancouver, **Oct 7**
 - CB Christina Burt, U Melbourne
 - YB Yao Ban, U Melbourne
- } **Sept 28**
-
- TUGS Gründungsservice TU Berlin, **Oct 5**



The CO@W Lecture Team of the first week (in the sequence of appearance)

MG	Martin Grötschel
CR	Christian Raack
AW	Axel Werner
IPG:	TB Timo Berthold
	KW Kati Wolter
	SH Stefan Heinz
	AG Ambros Gleixner
	TK
RB	Ralph Borndörfer
TK	Thorsten Koch

The CO@W program contains the names of all lecturers (there are more to come in the next two weeks), and all those helping with the exercises and support the course in various ways.



Tu 06.10. Excursion to a company

- Berlin **Siemens turbine production**
10:00-13:00 Visit of plant and discussion
13:00-14:00 Lunch
14:30-18:00 Visit of **Technikmuseum**

Who wants to go where?

- Berlin **Bayer Schering**
10:00-13:00 Visit of plant and discussion
13:00-14:00 Lunch
14:00-15:00 Going to Potsdam
15:00-17:00 **Visit of ViP (Verkehrsbetriebe in Potsdam)**

- Hamburg **HHLA Container Terminal**
07:00-10:00 Journey to Hamburg
10:15-11:45 Presentation of HHLA, CTA and control system
11:45-12:45 Lunch
12:45-14:15 Terminal tour
14:30-15:30 Discussion
15:30-18:30 Visit of Hamburg?
18:30-21:30 Back to Berlin

Wait until Wednesday,
there will be an auction!

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Who is attending this course?

- The [list](#) of participants
- The list by [country](#)

CO@W



Martin

Grötschel

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Berlin impressions

CO@W



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WE hope that you will spare a few minutes to visit interesting places in Berlin

- Saturday, 26.09.: 16:00-20:00 Museumsinsel
- Sunday, 27.09. free
- Sunday, 04.10. free
- Tuesday, 06.10.: Hamburg or Technikmuseum
- Friday, 09.10.: Barbecue

If you want to learn more about Berlin, just ask the Berliners here.



Sex in the city

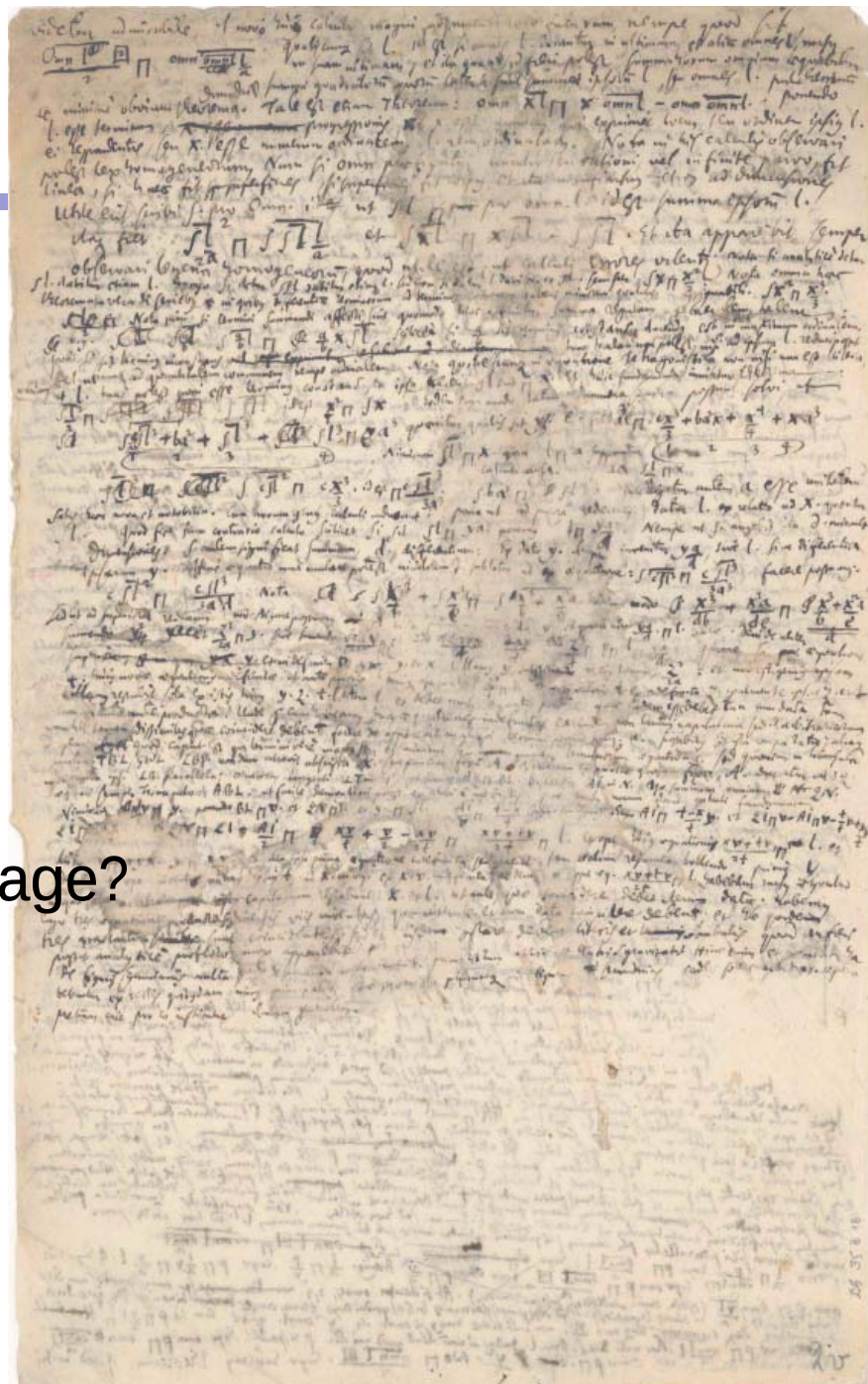
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LH XXXV 8, 18 Bl. 2v^o

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Copy of a
manuscript page by
Gottfried Wilhelm Leibniz



What is important about this page?



LH XXXV 8, 18 Bl. 2v°

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Handwritten manuscript page, likely a page from a book or a collection of papers. The text is written in a cursive script, possibly from the 17th or 18th century. The page contains several lines of text, including mathematical expressions and diagrams. The text is written in a dark ink on a light-colored paper. The page is numbered '18' in the top right corner. The text is written in a cursive script, possibly from the 17th or 18th century. The page contains several lines of text, including mathematical expressions and diagrams. The text is written in a dark ink on a light-colored paper. The page is numbered '18' in the top right corner.



Euler's traces in Berlin



Bayerische Landesvertretung, opposite Komischen Oper

Euler's traces in Berlin

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Eulerstraße and Euler-Kneipen (pubs) in Berlin-Wedding

Euler's traces in Berlin

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Eulerstraße and Euler-Kneipen (pubs) in Berlin-Wedding



Mathematics in the city

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James A. Garfield (1881)



My wife's book

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Leonhard Euler

GLÄNZENDE AUGEN ODER ANGSTSCHWEISS – WELCHER MATHEBUCH-TYP SIND SIE? Hier ist einmal eins für beide! Für diesen unverstaubten Streifzug durch Berlin benötigen Sie weder Zirkel noch Taschenrechner oder gar algebraische Formeln. Dieses Buch zeigt: Mathematik ist alltagstauglich, macht Spaß – und ist überall um uns herum! Historische Persönlichkeiten und Orte, berühmte Formeln, großartige Architektur, Kultur und Kunst – all das ist das mathematische Berlin. Viel Vergnügen!



GESCHICHTE DER MATHEMATIK IN BERLIN
Mehr als 500 Jahre mit Höhen und Tiefen, goldenen Zeiten, Kriegen und Ideologien prägten die Mathematik in Berlin – und wurden durch sie geprägt.



ORTE UND MATHEMATIKER Leibniz, Euler, Weierstraß (Bild), Kronecker – wo wer welche mathematischen Höchstleistungen in Berlin vollbracht hat – und wie man ihrer heute gedenkt.



BERLINER MATHEMATIK HEUTE Nicht nur das »Jahr der Mathematik« beschäftigt die Stadt: Mathematische Institute, Schulen und Vereinigungen in der aktuellen Matheszenen Berlins.



MATHEMATISCHE EXPONATE tauchen auf, wie und wo man sie gar nicht vermutet. Ob »6«-en oder 124,5°-Bogen, Skulpturen, Mosaiken an Gebäuden oder – wie hier – ein Ikosaeder im Hausgarten.



IRIS GRÖTSCHTEL kennt sich mit beiden aus, mit der Mathematik und mit der Stadt. Die ehemalige Studienrätin für Mathematik arbeitet seit zehn Jahren als zertifizierte Stadtführerin in Berlin.

ISBN 978-3-929829-92-1
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Wissenschaftsjahr 2009
Mathematik
Alles, was zählt

$e^{i\pi}$

DAS MATHEMATISCHE BERLIN

IRIS GRÖTSCHTEL

DAS MATHEMATISCHE BERLIN

HISTORISCHE SPUREN UND AKTUELLE SZENE

Wissenschaftsjahr 2009
Mathematik
Alles, was zählt



Fig. 40.
Morgenhorizont
Ein fürstlicher
hof von Königsberg
von der Colosseum
von Berlin gegen die
Seite von Altona gesehen

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Before I begin to talk about mathematics...

I have to advertise the institutions I am representing:

- Technische Universität Berlin
- Konrad-Zuse-Zentrum für Informationstechnik
- MATHEON
- Berlin Mathematical School





Technische Universität Berlin

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Akustische Holographie

Freitag, der 18. September 2009

Am 21. September präsentiert das European Bridges Ensemble unter der Leitung von Georg Hajdu multimediale Netzwerkkompositionen, die eigens für die Wellenfeldsyntheseanlage der TU Berlin angepasst wurden. Diese Beschallungsanlage ist die weltweit größte ihrer Art.

[▶ mehr](#)



Der TU-Hörsaal H 104: Ein 86 Meter langes Band aus 2700 Lautsprechern ermöglicht das Hören in 3-D - eine Art akustische Holographie.
© TU-Pressstelle/Dahl

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About the TU Berlin

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TU Berlin – Paving the way to the future

The internationally renowned Technische Universität Berlin is located in Germany's capital city at the heart of Europe. Our activities focus on building a distinctive profile, exceptional performance in research and teaching, excellent qualifications for our graduates and a forward-looking administration. The TU Berlin strives to promote the dissemination of knowledge and to facilitate technological progress by adhering to the principles of excellence and quality. Strong regional, national and international networking partnerships with science and industry are an important aspect in this regard.



The Main Building of the TU Berlin, as seen from the south.
© TU Berlin/Dahl

Our research and teaching endeavors can be characterized by a broad spectrum of academic disciplines, ranging from engineering science to natural science, planning science and economics, as well as the humanities and social sciences.

TU BERLIN – AN OVERVIEW

- 26850 students, including 5570 students from other countries
- 7 Schools
- 299 Professors
- 16 Junior Professors
- 1985 Research associates
- 1048 Externally-funded positions
- 90 Courses of study
- 1984 Staff in administration, libraries, central institutions and workshops
- 259.6 million euro in state subsidies for the year 2008
- 81.2 million euro in external funding for the year 2007
- Average of 30 habilitations and 400 doctoral degrees granted each year
- Approximately 150 trainees each year in 16 professions

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TU Mathematics

co@w



Technische Universität Berlin
Faculty II – Mathematics and Natural Sciences
Institute of Mathematics



Deutsche Version

Wissenschaftsjahr 2008

Mathematik
Alles, was zählt



Local MathNet Guide

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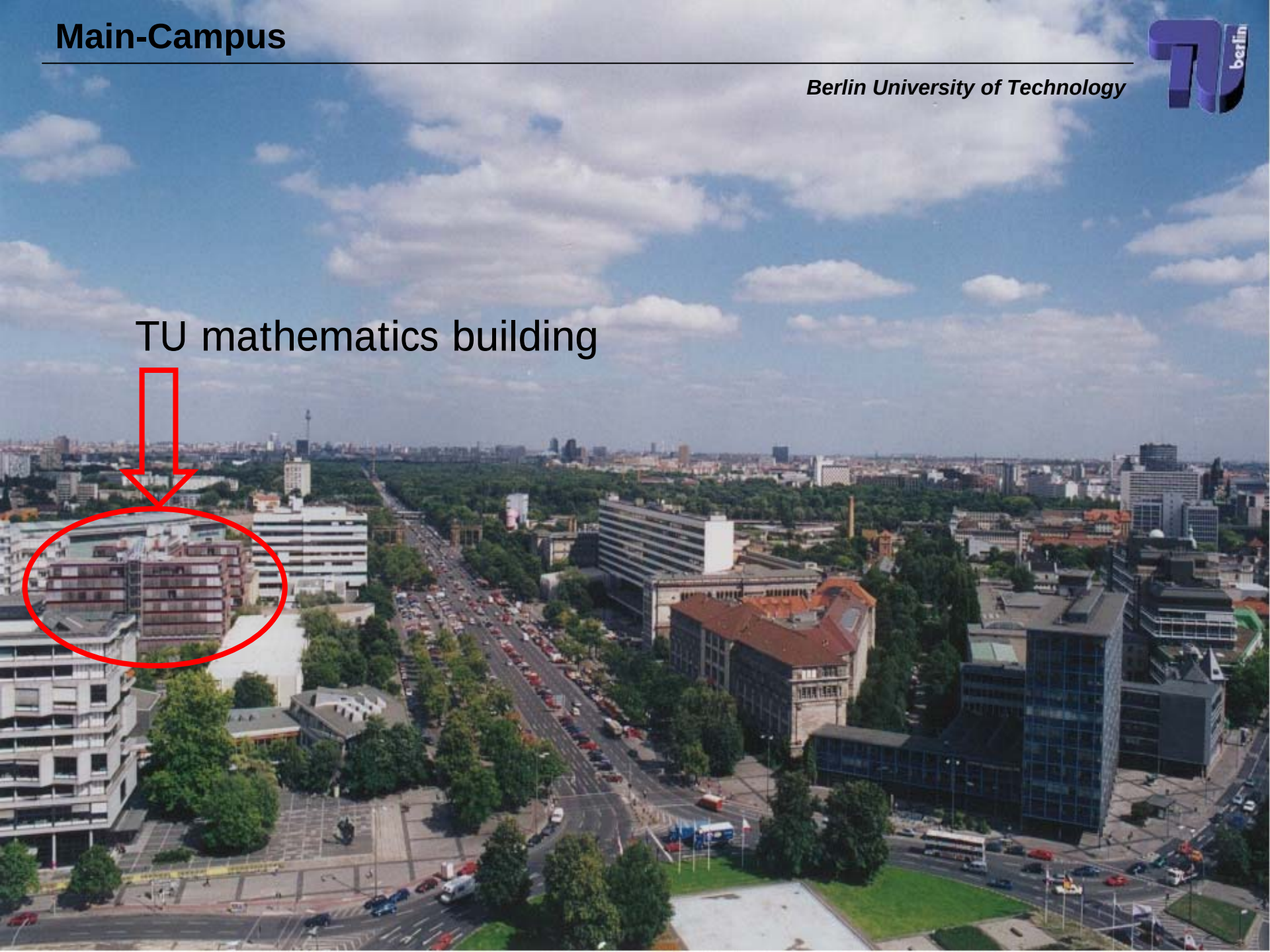
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Sorry, but pages marked with are currently only available in German language.

TU mathematics building





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Zuse Institute Berlin

The Zuse Institute Berlin is a research institute for applied mathematics and computer science. Our research and service is driven by the principle **Fast Algorithms - Fast Computers**: We provide solutions for complex problems in science, engineering, environment, and society - solutions that often require innovative approaches. In close cooperation with partners from science, economy, and society we develop mathematical models and efficient algorithms. For the users of our high-performance computers we provide specialized consulting services.



The Berliner **Konrad Zuse**, inventor of the first freely programmable computer and namesake of our institution, was already well-known in his own time for putting innovative ideas into practice, and making these accessible to a wide user community. Today, our areas of expertise include applications in medicine, biotechnology, optimization of traffic and transport, logistics, electronics, telecommunication, and many others.



ZIB from the air



Konrad Zuse (1910 – 1995)

**Dipl.-Ing. TU Berlin
Civil Engineering**

**As a student at TU Berlin
inventor of the first
program-controlled
electrical computer
calculating digitally
with electro-mechanical
switches („relais“).**

**The photo shows K. Zuse
in 1985 with a replica of
his first computer of 1938.**



Zuse at Zuse-Zentrum

CO@W



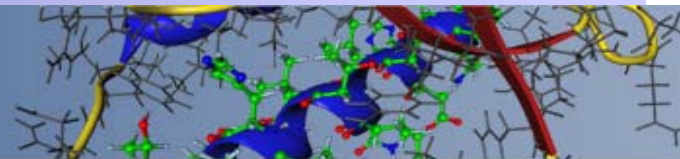
Konrad Zuse at his last visit
of the old ZIB 1994



DFG-Forschungszentrum MATHEON



DFG Research Center MATHEON
Mathematics for key technologies



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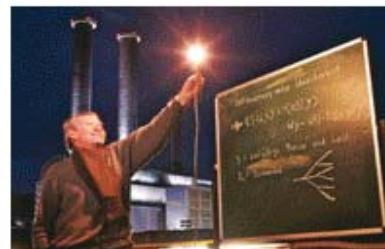
Survey of MATHEON on October 8



So sehen Sieger aus! Am 22. August wurden auf der Bühne des Kulturstadions zur Leichtathletik-WM am Brandenburger Tor die Sieger des MATHEATHLON geehrt. - [mehr](#)



MATHEON in DFG Science TV. [more](#)



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DFG Research Center MATHEON develops mathematics for key technologies and supports partners in industry, economy and science. We also cooperate with schools and the general public. Founded in 2002, MATHEON is a joint initiative of the three Berlin universities (FU, HU and TU) and the mathematical research centers (WIAS and ZIB).

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IMPORTANT TOPICS

Mathe klingt gut
(Website)



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Berlin 2009 Block Course "Combinatorial Optimization at Work"
(Website)

Combinatorial Optimization at Work II will take place from September 21 until October 9, 2009 at Zuse Institute Berlin.

[more](#) >

Reliable Methods Of Mathematical Modeling

The workshop brings together specialists developing mathematical and computational methods intended to increase the reliability of the numerical results obtained in various mathematical modeling methods.

[more](#) >

Prof. Mehrmann neues acatech-Mitglied

I **Optimization and discrete mathematics**

W. Römisch (HU)

M. Skutella (TU)

G. M. Ziegler (TU)

II **Numerical analysis and scientific computing**

R. Kornhuber (FU)

R. Schneider (TU)

H. Yserentant (TU))

III **Applied and stochastic analysis**

P. Imkeller (HU)

C. Lasser (FU)

A. Mielke (FU, WIAS)

including: **scientists in charge**

MATHEON research

Application areas

A Life sciences

A. Bockmayr (FU), P. Deuflhard (FU, ZIB), Ch. Schütte (FU)

B Logistics, traffic and telecommunication networks

M. Grötschel (TU, ZIB), R. Möhring (TU), M. Skutella (TU)

C Production

C. Carstensen (HU), D. Hömberg (TU, WIAS), F. Tröltzsch (TU)

D Circuit Simulation and Opto-Electronic Devices

V. Mehrmann (TU), A. Mielke (HU, WIAS), F. Schmidt (ZIB)

E Finance

D. Becherer (HU), P. Imkeller (HU)

F Visualization

K. Polthier (FU), J. Sullivan (TU), G. M. Ziegler (TU)

G Education, Outreach, Administration

J. Kramer (HU)

including: **scientists in charge**





- Block Course "Combinatorial Optimization at Work" II
- BMS Fridays in the Winter Semester
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- Welcome

Berlin Mathematical School

Survey of BMS on October 8



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Welcome

The Berlin Mathematical School (BMS) is a joint graduate school of the mathematics departments of the three major Berlin universities, [TU Berlin](#), [FU Berlin](#), and [HU Berlin](#). It offers

- a uniform setting for graduate studies (**from Bachelor to Ph.D.**) in mathematics in Berlin,
- a coordinated, highly diverse **course program** in English (Phase I, from bachelor to qualifying exams in two years),
- access to all **math research groups** in Berlin for a PhD (Phase II), in particular, to the **DFG Research Training Groups (Graduiertenkollegs)** and other ongoing **research projects**,
- intensive mentoring during the whole duration of studies, and
- support in non mathematical issues ranging from housing to visas and from child care to language courses.

Have a look at our [academic profile!](#)



We invite excellent mathematics students from Berlin, Germany, Europe and all over the world to join BMS - and to make good use of the ample opportunities offered by the rich and diverse mathematics teaching and [research environment](#).

Depending on the individual background, admission is to Phase I (typically with a bachelor) or directly to Phase II (for example, for students holding a master/diploma).



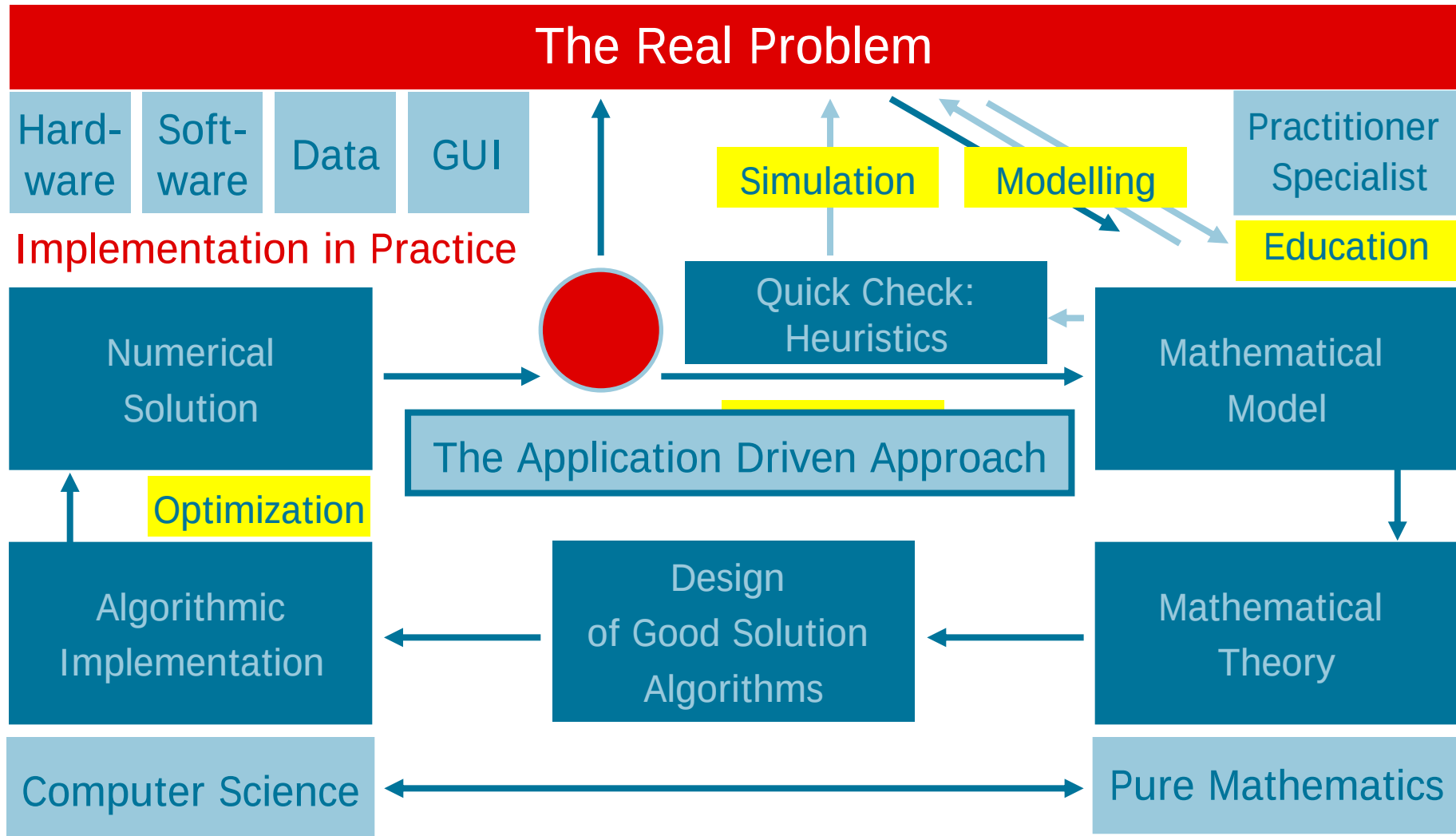
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The problem solving cycle in modern applied mathematics



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briefly: CO@W Berlin

The End

Martin Grötschel

- Institut für Mathematik, Technische Universität Berlin (TUB)
- DFG-Forschungszentrum “Mathematik für Schlüsseltechnologien” (MATHEON)
- Konrad-Zuse-Zentrum für Informationstechnik Berlin (ZIB)

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