

10A1 Lecture

Summary and Final Remarks

Martin Grötschel

Beijing Block Course

“Combinatorial Optimization at Work”

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CO Problems & Applications

General problems:

- Linear programming
- Integer, mixed integer, and 0/1-programming

Algorithmic issues:

- Polynomial time solvability
- NP-hardness

Solution techniques:

- Polyhedral combinatorics
- Cutting plane algorithms
- Branch&cut&price
- Column generation
- Heuristics
- Lagrangean relaxation



CO Problems & Applications

Prototypical CO problems:

- Travelling salesman problem
- Set partitioning
- Network flow problems
- Shortest path problem
- Spanning tree problem
- ...



CO Problems & Applications

Applications:

Several aspects of chip verification

Chip design:

- Global placement
- Local placement
- Global (homotopic) routing
- Local routing
- Layer assignment & via minimization
- Compactification



CO Problems & Applications

Applications:

Printed circuit board production

- Task partitioning
- Component placement
- Wire routing
- Layer assignment (via minimization)
- Hole drilling (modelling the objective)



CO Problems & Applications

Applications:

- Garbage collection (Chinese postman)
- Grave sequencing in archeology
- Beef cutting (Bixby)



CO Problems & Applications

Applications:

Telecommunication:

- Frequency Assignment in GSM
- The UMTS Radio Interface
- Locating the Nodes of a Network
- Balancing the Load of Signaling Transfer Points
- Integrated Topology, Capacity, and Routing Optimization as well as Survivability Planning
- Planning IP Networks
- IP Routing
- Optical Networks



CO Problems & Applications

Applications:

Online optimization:

- Yellow angels
- Stacker crane scheduling
- Elevator control
- Greeting cards commissioning
- (Bin packing)
- (Ski rental)
- Online TSP and online DARP



CO Problems & Applications

Applications:

Transportation & Logistics:

- Factory logistics (AGVs, conveyors, etc.)
- Harbour optimization issues
- Telebus: Transporting disabled persons
- Network Planning
- Line Planning
- Price and Frequency Planning
- Vehicle Scheduling
- Duty Scheduling
- Integrated Vehicle and Duty Scheduling
- Track Auctioning



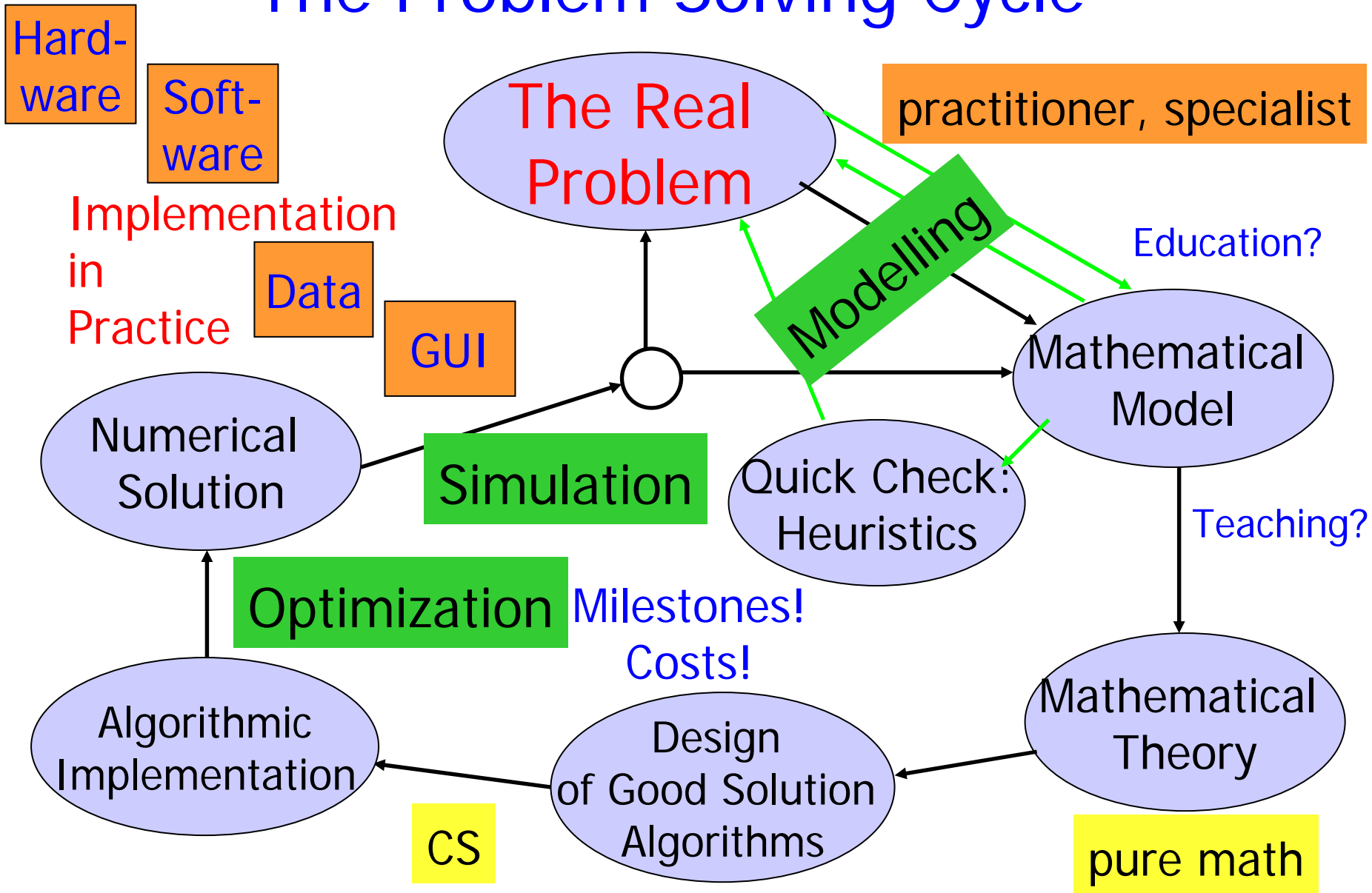
CO Problems & Applications

Applications:

- We have introduced in some detail about 40 real-world problems to which methods of combinatorial optimization can be applied.
- And we have mentioned additional interesting applications in passing.
- We have outlined
 - what could be achieved in practice and
 - what the obstacles to implementation have been.
- And we have provided a realistic picture of the “solution environments”.



The Problem Solving Cycle



In Modern Applied Mathematics

CO Problems & Applications

We hope that you know now more about

“mathematics and the real world”



Questionnaire

- Was it worth spending two full weeks on such a course?
- What did you like?
- What did you not like?



Questionnaire

- Was there too much teaching (in a very short time period)?
- Is a block course an adequate format for such a lecture series?
- What could be a more suitable format?
- Were the classes too long?
- Was the level of teaching “right”?
- Should there be more details about
 - the problems and their data
 - the theory behind the problem
 - the algorithms designed and used
 - the solution and implementation in practice?
- Should more theory be taught?
- Should one concentrate only on “little” problems that can be explained easily?
- Does it make sense to give broad overviews?



Questionnaire

- Should there be more exercises?
- Did you like the exercises?
- Should the exercises be in a different form?
- Was it a good idea to make software and data available on the Web?
- Is it a good idea to use laptops in the exercises?
- What else would you like to see in the Power Point presentations?
- Was it worth visiting Volkswagen?
- Should one try to include such an excursion if the course is repeated?



Questionnaire

- What would you like to see written?
- This concerns depth, length and detail of the articles to be written.
- Should there be only articles on individual applications?
- Should there be overview articles?
- Should there also be some theory surveys or should these be integrated into the application articles?



The CO at Work Project

The final product of this “Combinatorial Optimization at Work” project (if we succeed finishing it) will consist of several items.

- There will be a printed book that contains the articles.
- The book will be available for download (for free) from the Web.
- All articles will be offered on the Web.
- There will be updates from time to time, including new articles.
- Data of real problem instances will be made available.
- Some software for the solution of the problems addressed will be made available for free on the Web.



CD-ROM/USB-Stick

- All Power Point presentations are on the CD
- The films shown
- The final program
- Some photos



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**Thanks for your
participation**



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