Project B20

Optimization of gas transport

DFG Research Center MATHEON
mathematics for key technologies
www.matheon.de

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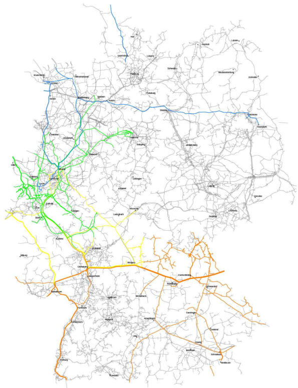
Domain of Expertise: Energy and utilities

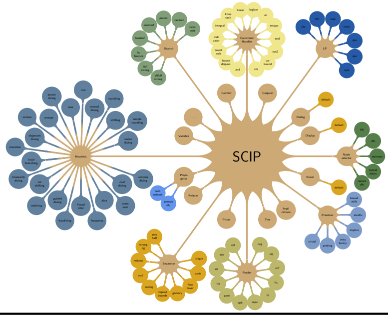
Background

- political regulations (e.g., Gasnetzzugangs-verordnung) led to a strict separation of gas trading and gas transport in Germany
- these newly imposed political requirements influence the technical processes of gas transport
- as a result, the already complex task of planning and operating gas networks becomes even more challenging
- however, suitable algorithms or software are currently not available to solve today's gas transport optimization problems



Project Goal

Integration of aspects from Mixed Integer Programming, Nonlinear Programming, Constraint Programming, and Stochastic Programming into a general purpose solver.



Mathematical Aspects of Gas Transport

Mixed Integer Programming

Network configuration and design

$$q_{u,v} = 0 \quad \vee \quad \begin{matrix} q_{u,v}^{\min} \le q_{u,v} \le q_{u,v}^{\max} \\ p_u = p_v \end{matrix}$$

$\Rightarrow$ Combinatorial decisions

Nonlinear Programming

Pressure loss in a pipeline

$$p_v^2 = \left(p_u^2 - \Lambda |q_{u,v}| q_{u,v} \frac{e^S - 1}{S} \right) e^{-S}$$

$\Rightarrow$ Nonlinear nonconvex constraints

Constraint Programming

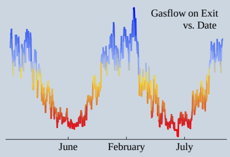
Operating map of a compressor station can be well represented by a union of nested polyhedra

$\Rightarrow$ Disjunction constraints

Stochastic Programming

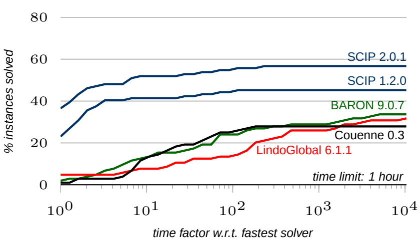
Demand of gas underlies uncertainties, e.g., weather

$\Rightarrow$ Chance constraints

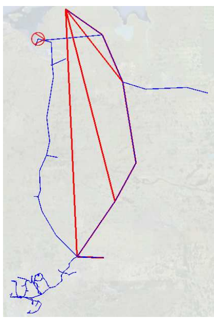


Achievements

- ForNE solves **topology planning** problems on "H-Nord" with SCIP
- SCIP supports **quadratic and cumulative scheduling constraints**
- **LNS heuristics** extended to MINLP and general CIPs
- new **MINLP heuristic "Undercover"**



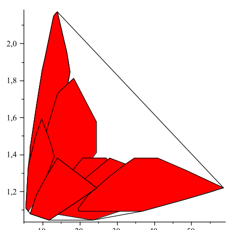
Performance on 104 MIQQP benchmark instances
(from MINLPLib and testsets of J.N. Hooker, H. Mittelmann, J.P. Vielma, IBM/CMU)



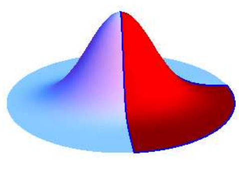
Open Grid Europe's "H-Nord" network (594 nodes, 624 edges)

Future Plans

- solve **larger topology planning instances**
- support **general MINLPs** in SCIP
- **transfer of more MIP/CP technology** to MINLP/CIP
- handling of **disjunction/conjunction constraints**
- support for **chance constraints**



Operating map of compressor (nested union of convex sets)



Probability density function of normal distribution

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