

57. Workshop über Komplexitätstheorie, Datenstrukturen und Effiziente Algorithmen

Programm

Köln, 3. Juni 2009, Hörsaal XI a, Hauptgebäude

- 10.00 – 10.30** *Kaffeepause und Begrüßung*
- 10.30 – 11.15** Ulrich M. Schwarz
A 2-approximation for 2D Bin Packing
- 11.15 – 12.00** Michael Thomas
*The Complexity of Inference in Propositional Circum-
scription*
- 12.00 – 12.45** Tatjana Schmidt
Aspects of Mixed Horn Formulas
- 12.45 – 14.15** *Mittagspause*
- 14.15 – 15.00** Lars Prädel
*How to Maximize the Total Area of Rectangles Packed
into a Rectangle?*
- 15.00 – 15.45** Olaf Beyersdorff
Proving Propositional Tautologies with the Help of Advice
- 15.45 – 16.15** *Kaffeepause*
- 16.15 – 17.00** Marcel Ochel
Approximability of OFDMA Scheduling

A 2-approximation for 2D Bin Packing

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We study the two-dimensional geometrical bin packing problem (2DBP): given a list of rectangles, provide a packing of all these into the smallest possible number of 1×1 bins without rotating the rectangles. This problem is the obvious generalization of the classical (one-dimensional) bin packing problem and has a wide variety of practical applications, such as ad placement and VLSI chip design.

Unlike the one-dimensional counterpart, 2DBP cannot be approximated to $2 - \epsilon$ in polynomial time, whether or not the items may be rotated, and it does not admit an asymptotical approximation scheme (APTAS).

We present a 2-approximation algorithm, which improves over the previous best known ratio of 3, matches the best results for the rotational case and also matches the known lower bound of approximability. Our approach combines a previously known algorithm with asymptotic ratio better than two [3] with a recently-discovered PTAS [2] for a related 2D knapsack problem and a new algorithm that can pack instances into $\text{OPT} + 2$ bins for any constant OPT .

These results are joint work with Lars Prädél and Klaus Jansen.

References

- [1] Jansen, K., Prädél, L., Schwarz, U. M.: A 2-approximation for 2D bin packing. Technical Report 0904, Universität Kiel, 2009.
- [2] Jansen, K., Prädél, L.: How to maximize the total area of rectangles packed into a rectangle? Technical Report 0908, Universität Kiel, 2009.
- [3] Bansal, N., Caprara, A., Sviridenko, M.: Improved approximation algorithms for multidimensional bin packing problems. In: Proceedings of FOCS 2006.

The Complexity of Inference in Propositional Circumscription

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Circumscription is one of the most important formalisms for reasoning with incomplete information. It is equivalent to reasoning under the *extended closed world assumption*, which allows to conclude that the facts derivable from a given knowledge base are all facts that satisfy a given property. In this paper, we study the computational complexity of several formalizations of inference in propositional circumscription for the case that the knowledge base is described by a propositional theory using only a restricted set of Boolean functions. To systematically cover all possible sets of Boolean functions, we use Post's lattice. With its help, we determine the complexity of circumscriptive inference for all but two possible classes of Boolean functions. Each of these problems is shown to be either Π_2^P -complete, coNP-complete, or contained in .

In particular, we show that in the general case, unless $P = NP$, only literal theories admit polynomial-time algorithms, while for some restricted variants the tractability border is the same as for classical propositional inference.

Some aspects of Mixed Horn Formulas

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We consider various aspects of the Mixed Horn formula class (MHF) [2]. A formula $F \in \text{MHF}$ consists of a 2-CNF part P and a Horn part H . We propose that MHF has a central relevance in CNF, because many prominent NP-complete problems listed in [1], e.g. Feedback Vertex Set, Vertex Cover, Dominating Set and Hitting Set can easily be encoded as MHF. Furthermore we show that SAT for some interesting subclasses of MHF remains NP-complete. Finally we provide algorithms for two of these subclasses solving SAT in a better running time than $O(2^{0.5284n}) = O((\sqrt[3]{3})^n)$ which is the best bound for MHF so far, over n variables [2]. One of these subclasses consists of formulas, where the Horn part is negative monotone and the variable graph corresponding to the positive 2-CNF part P consists of disjoint triangles only which is the hardest class regarding the best bound mentioned above. For this class we provide an algorithm and present the running times for the k -uniform cases, where $k \in \{3, 4, 5, 6\}$. Regarding the other subclass consisting of certain k -uniform linear mixed Horn formulas, we provide an algorithm solving SAT in time $O((\sqrt[k]{k})^n)$, for $k \geq 4$.

Results are joint work with Stefan Porschen and Ewald Speckenmeyer.

References

- [1] Karp, R.M.: Reducibility Among Combinatorial Problems. In Complexity of Computer Computations, Proc. Sympos. IBM Thomas J. Watson Res. Center, Yorktown Heights, N.Y.. New York: Plenum, p.85-103. 1972.
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How to Maximize the Total Area of Rectangles Packed into a Rectangle?

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We study an interesting geometric optimization problem called Rectangle Packing with Area Maximization (RPA). We are given a set of rectangles and a rectangular target area called bin. The goal is to find a feasible packing of a subset of the given rectangles into the bin, i.e. an orthogonal packing without rotation and overlap. The objective is to maximize the total area of rectangles packed. This problem is a generalization of the Subset Sum problem, which is one of the most fundamental and well-known problems in combinatorial optimization and has many practical applications, such as VLSI layout and the cutting problem.

RPA is strongly \mathcal{NP} -hard even for squares, therefore there is no fully polynomial time approximation scheme (FPTAS) for this problem, unless $\mathcal{P} = \mathcal{NP}$. The previously best result is a $(1/2 - \varepsilon)$ -approximation by Jansen & Zhang [2] for our problem. We present a polynomial time approximation scheme (PTAS) for this problem, i.e. a family of algorithms which compute for any accuracy $\varepsilon > 0$ in polynomial time a solution with ratio $(1 - \varepsilon)$.

These results are joint work with Nikhil Bansal, Alberto Caprara, Klaus Jansen and Maxim Sviridenko.

References

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- [2] K. Jansen and G. Zhang: On rectangle packing: maximizing benefits. In: *Algorithmica*, volume 4, pages 323-342, 2007

Proving Propositional Tautologies with the Help of Advice

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One of the starting points of propositional proof complexity is the seminal paper by Cook and Reckhow [5], where they defined propositional proof systems as poly-time computable functions which have all propositional tautologies as their range. Motivated by provability consequences in bounded arithmetic, Cook and Krajíček [4] have recently started the investigation of proof systems which are computed by poly-time functions using advice. While this yields a more powerful model, it is also less directly applicable in practice.

In this talk we describe recent results on this new model of proof systems. In particular, we investigate the following questions:

1. Do there exist optimal or p-optimal proof systems with advice?
2. Do there exist polynomially bounded proof systems with advice?
3. Does the usage of advice shorten propositional proofs?

While the first question receives an affirmative answer [4, 2], we obtain different characterizations for the second one, depending on the complexity of the underlying language and the amount and type of the advice used by the proof system [1]. To approach the third question, we compare proof systems with advice with both classical advice-free systems and proof systems using an easy oracle [3].

Results described in the talk are joint work with Johannes Köbler and Sebastian Müller [1, 2, 3].

References

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Approximability of OFDMA Scheduling

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We study the problem of downlink OFDMA, which is a central problem faced by implementing wireless or other modes of broadband communication: data has to be sent from a base station to $n \geq 1$ many *terminals* using a set of $m \geq n$ orthogonal subcarriers also called *channels*. We consider the model of *uniformly related channels*, where each channel comes with an associated *cost* parameter p_j which is the reciprocal value to the signal-to-noise ratio of the channel. By applying the formulas for the Shannon capacity, the energy required to send data with a rate of r_j over channel j is assumed to be $p_j(2^{r_j} - 1)$. For given data rates d_i for each terminal i an (exclusive) assignment of channels to terminals and an allocation of data rates on these channels has to be found such that the total transmit power is minimized. This variant will be called Min-Power OFDMA. We also consider a natural dual version called Max-Rate OFDMA. Instead of minimizing the total transmit power satisfying given demands, one strives to maximize the minimal fraction λ of demand that can be achieved without violating a specified energy bound.

OFDMA — a composition of OFDM (orthogonal frequency division multiplexing) and FDMA (frequency-division multiple-access) — has become an increasingly popular technology in the area of broadband communication, because of its high robustness to noise and inter-symbol interference. There have been numerous attempts by the engineering community to solve Min-Power-/Max-Rate OFDMA, but because of the widely assumed intractability of the problem these were mostly heuristics not guaranteeing any bound on the quality of the found solutions or the running time.

In this talk we will prove that Min-Power OFDMA is NP-hard and cannot be approximated within any polynomial time computable factor. In contrast to this, we develop a polynomial time approximation scheme (PTAS) for the Max-Rate OFDMA problem with uniform demands, that for any given constant ϵ computes a schedule satisfying a minimum rate of at least $(1 - \epsilon)\lambda^{\text{opt}}d$. Up to our knowledge no polynomial time approximation algorithm for Max-Rate OFDMA with a theoretical worst-case bound has been known to date. The scheme will be constructed by adapting techniques from the area of makespan scheduling [2]. As a byproduct a PTAS different from known ones [1, 3] will be given for the Santa Claus Scheduling problem on identical machines. We will then look at the case of Max-Rate OFDMA with general demands. As our PTAS does not apply there, we use a different approach and obtain a simple 1/2-approximation algorithm.

This is joint work with Berthold Vöcking.

References

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