Period Closing Report
2013/09/01 – 2015/08/31
for the research project # **108947**

Optimization Methods for Cloud Computing and Communications

The order of the presentation of the results follows that of the original research plan submitted in 2013. The list of the references of the present document contains 102 items, including 46. research articles (33 already published or accepted for publications and 13 submitted, under review), 1 book and 55 other items (book chapters, conference publications).

Part 1 (Scalable Data Center and Communication Architectures)

In [Babarczi 1], we have summarized our previous results in all-optical failure localization. Starting from the introduction of basic protection and restoration approaches we identify the trade-off between restoration time and redundancy in all of these methods. Throughout the book, we build up an all-optical protection framework, which eliminates this trade-off, and makes the application of an arbitrary all-optical restoration scheme viable in practice. Such a scheme has utmost importance in dynamic optical networks, which serves as the physical infrastructure of most data centers, thus, enables a reliable transport infrastructure for future cloud services. In order to reach this goal, we have introduced the concept of monitoring trails (m-trails), which are simple or non-simple supervisory paths of the network. Here, the task is to deploy m-trails in the network in a way that any link failure can be unambiguously identified by inspecting the on-off status of these paths.

In [Babarczi 1], the research results of failure localization via a central controller are summarized. However, the failure localization task have to be distributed between individual routing elements in order to reach an all-optical signaling-free protection framework. The basic concept of the distributed failure localization framework, which is suitable for cloud communication networks as well, is introduced in [Babarczi 3], where the notion of neighborhood is defined. The neighborhood of a node (i.e., routing entity) contains the links, for which the given node have to respond in the restoration process of the disrupted active paths upon link failure. Assuming that the link failure, thus, the corresponding switching operation, can be unambiguously identified at each node with inspecting only the on-off status of the traversing m-trails, an all-optical signalling free framework is proposed, which is beneficial both from the viewpoint of restoration time and redundancy. The model was later generalized to node failures in [Tapolcai 1], and to optical packet switching [Tapolcai 3].

We investigated the size of the forwarding tables in a network with shortest path hop-by-hop routing. In [Kőrősi 4] we studied what is the fundamental reason the practical Internet routing tables are surprisingly small

Graph coloring, various graph parameters, related to routing and wavelength assignment (see also Part 4)

In [Toth 1, 2] we investigate a communication setup where a source output is sent through a free noisy channel first and an additional codeword is sent through a noiseless but expensive channel later. With the help of the second message the decoder should be able to decide with zero-error whether its decoding of the first message was error-free. This scenario leads to the definition of a digraph parameter that generalizes Witsenhausen's zero-error rate for directed graphs. We investigate this new parameter for some specific directed graphs and explore its relations to other digraph parameters like Sperner capacity and dichromatic number.

The independence ratio of a graph is defined as the ratio of the independence number and the number of vertices. In [Toth 3] we determine the asymptotic value of the independence ratio with respect to the direct graph power for every graph, answering a question of Alon and Lubetzky. From the result we immediately obtain the proof of the conjecture of Brown, Nowakowski and Rall, stating that the ultimate categorical independence ratio of the disjoint union of two graphs is the maximum of the value of the parameter for the two graphs. We also show that the parameter is computable.

Denote by $c(r,b,k)$ the smallest positive integer c such that the vertex set of any r-uniform, k-edge colored (non trivial) hypergraph with independence number b can be covered by at most c monochromatic connected components. This concept generalizes several previously studied problems among which some have already been solved. In [Toth 4] we show that $c(r,r,r)=2$ for any r (at least 2). The general question seems to be really hard, there is no reasonable conjecture for the value of $c(r,b,k)$ yet.

In [Wiener 7] we show that depth first search can be used to give a proper coloring of signed graphs G using at most $\Delta(G)$ colors, provided G is different from a balanced complete graph, a balanced cycle of odd length, and an unbalanced cycle of even length, thus giving a new, short proof to the generalization of Brooks' theorem to signed graphs, first proved by Macajova, Raspaud, and Skoviera.

The aim of [Mann 17] is to assess the typical-case complexity of backtracking-based graph coloring algorithms on random graphs, as a function of the number of available colors. It is known that the complexity peaks at the colorability threshold, i.e., at χ-1 or χ, where χ is the chromatic number of the graph. We use list coloring to simulate coloring with a fractional number of colors, making it possible to draw a more detailed picture of the complexity landscape between χ -1 and χ.

In [Soltész 1 we generalize a theorem of Feder and Subi about edge colorings of the graph of the n-dimensional cube. Our work extends their result to arbitrary graphs.

Hamiltonicity and similar questions related to survival of link outages

In [Wiener 1] we generalize the concept of hypohamiltonian and hypotraceable graphs by introducing the so-called l-leaf-critic graphs. We show that such graphs exist for every l>1 (which is not straightforward; even the existence of hypotraceable graphs was an open problem in the seventies) and prove some structural type theorems concerning them.

Motivated by questions concerning optical networks, in 2003 Gargano, Hammar, Hell, Stacho, and Vaccaro defined the notions of spanning spiders and arachnoid graphs. Traceable graphs are obviously arachnoid, and Gargano et al. observed that hypotraceable graphs are also easily seen to be arachnoid. However, they did not find any other arachnoid graphs, and asked the question whether they exist. The main goal of [Wiener 3] is to answer this question in the affirmative, moreover, we show that for any prescribed graph *H*, there exists a non-traceable, non-hypotraceable, arachnoid graph that contains *H* as an induced subgraph.

We also explore [Wiener 4] connections with a family of graphs introduced by Grünbaum in correspondence with the problem of finding graphs without concurrent longest paths.

Results related toVLSI routing

In [Kiss 1] two special cases of the routing are discussed first, namely if all the terminals are either on a single face (SALP - Single Active Layer Problem) or on two opposite faces (3DCRP - 3-Dimensional Channel Routing Problem). However if the terminals are on two adjacent faces, special problems arise. We present a polynomial algorithm for this problem.

In [Kiss 2, 3] we prove that combining these algorithms one can solve any given problem on cubes and we give some polynomial time algorithms to find these solutions.

The above solutions are theoretical results proving only the existence of a solution like this, but these universal spacings are too large to make a solution realizable in the real life. An effective decreasing technique for the 3-dimensional saddle routing problem is presented in [Kiss 4] in order to drastically reduce these values of spacings. Then this optimization is generalized for other 3-dimensional VLSI routing problems too.

Surprisingly, minimizing the maximal value of the necessary spacing might increase the total volume of the solution, as shown in [Kiss 9].

Part 2 (Energy Efficient Backbone Infrastucture)

We investigated how to handle failure at higher layers. Our focus was IP Fast Re-Route with Loop Free Alternate. In [Rétvári 1] we developed new network design algorithms that can compute the minimum set of virtual nodes and links needed to achieve 100% single failure resistancy.

We also developed data structures for fast IP lookup. In [Kőrösi 1] we compressed IP forwarding tables. In [Kőrösi 2] we compressed multiple forwarding tables for different virtual networks. In [Rétvári 3] our focus was a closely related problem of combinatorial ranking and unranking.

Another direction to lower effect of the trade-off is to keep the merits of well known protection approaches, while their redundancy, i.e., capacity consumption is lowered. A novel direction in dynamic environments and virtual cloud networks is to introduce the concept of intra-session network coding, where instead of the traditional store-and-forward concept, the routers are allowed to perform in-network operation of the data, e.g., create the bitwise exclusive OR of two packets before sending it out. However, in order to ensure dynamic operation, we limit such operations only for the packets of the same connection, i.e., intra-session coding is allowed. In [Tapolcai 2], we made a step further in the practical implementation of intra-session network coding in cloud networks, as we have shown that all benefits of traditional routing approaches can be reached by coding only at the source and destination node, while the capacity consumption can be reduced by 10-20% in some practical scenarios.

Note that although beneficial, with the application of network coding multi-path routing is required, which is hardly supported in current network and routing architectures. Thus, in [Babarczi 2] the routing concept of multistage Bloom filters is introduced, where instead of the end-point addresses (i.e., IP address) of the destination nodes, link identifiers are used for packet forwarding. This approach not only supports well the multi-path routing concept of network coding [Tapolcai 2], but also better suited for several cloud concepts, such as publish/subscribe architecture and Information Centric Networking (ICN). Our multistage architecture enables the Internet-wide adoption of this forwarding concept, as the main design goal was to design a scalable scheme, which can keep up with the unforgivingly growing size of data centers and cloud networks.

After the initial steps made in the implementation of intra-session network coding in cloud networks, we have further demonstrated the benefits of resilient flow decomposition (RFD). Remember, in RFD, coding is necessary only at the source and destination node, while the capacity consumption of protection approaches providing instantaneous recovery can be reduced by a maximum of 25%. We have shown [Babarczi 4] that in the unconstrained scenario this benefit can be reached with polynomial-time algorithms, while the problem turns to be hard when some nodes or links have some resource limitations. We thoroughly investigated the RFD approach and compared to traditional routing (store-and-forward) based approaches [Babarczi 5] in different failure scenarios. A cloud-ready implementation of our coding-based architecture [Babarczi 4] was also presented in [Babarczi 5]. As a last step, we extended the cost minimization model in [Babarczi 4] with an additional additive constraint along the forwarding paths [Babarczi 6]. Note that the additive metric is delay in the model of [Babarczi 6] but it can be generalized to energy consumption or to arbitrary additive link metric.

In order to survive single link outages and support the multiple forwarding path architecture of network coding based approaches [Babarczi 4-6], we have further investigated multipath routing [Rétvári 4]. In specific, by keeping incremental deployment in mind, we have investigated the trade-off between scalability and path length gap, i.e., the price we have to pay for longer paths in order to limit the forwarding table entries per destination to two. We have shown that this gap to optimum in path length is negligible in most scenarios, which enables the proliferation of multipath routing in cloud networks.

We also studied how to detect faults in linear decoders and encoders, which are the main building blocks of the widely used forward error correction code modules. Our work, which is based on group testing, won the best paper award at the 16th HPSR conference [Tapolcai 4].

Recently two conference articles were accepted [Tapolcai 5, 6] on our results of failure localization in optical backbone networks. We proposed constructions and heuristic algorithms for network wide localization of node failures.

We also investigated related addressing issues. We presented a DEMO [Gulyás 1] of Software Defined Networking, a theoretical framework for scalable inter domain routing [Rétvári 2, Kőrösi 3], and multi-path routing [Gulyás 2].

Cloud providers must allocate virtual machines (VMs) to physical machines (PMs) such that application performance requirements are met, PMs are well utilized but not overloaded, and overall power consumption is minimized. This is a complex optimization problem, for which multiple problem formulations and solution algorithms have been proposed. [Mann 7] presents a survey of the relevant literature.

Most algorithms that have been proposed for the VM allocation problem are simple heuristics, without any performance guarantees. In [Mann 8], we give formal proofs that some of the proposed heuristics are actually approximation algorithms for some important subproblems, like the optimal selection of VMs to migrate from an overloaded host.

In order to deploy critical applications in a compute cloud, extra constraints are needed to ensure a sufficient level of performance isolation. In [Mann 9] we formalized the deployment optimization problem to include both provider and tenant objectives: consolidation opportunities together with guarantees for the performance of critical applications. The resulting problem is solved using integer linear programming.

In [Mann 10], we addressed the problem of selecting data centers (DCs) for a large-scale task, requiring thousands of virtual machines, in a distributed cloud consisting of dozens of DCs, with the objective of minimizing inter-DC communication. We proved that the problem is strongly NP-hard and devised a heuristic for it based on the A* algorithm. Extensive simulation results show the superior performance of our algorithm over simpler heuristics commonly proposed for contemporary cloud systems.

Most of the existing approaches to the virtual machine placement problem consider the computational capacity of physical machines and the computational load of virtual machines as one-dimensional quantities. With multicore processors, however, this is not a realistic model. In [Mann 12], we investigate the effects of multicore scheduling issues on VM placement. We use constraint programming techniques to devise algorithms that can effectively cope with the resulting huge search space.

Many algorithms have been proposed to solve the virtual machine allocation problem. Unfortunately, these approaches are hardly comparable because they deal with slightly different problem formulations. [Mann 13] proposes some canonical versions of the VM allocation problem and defines them formally, thus fostering comparability of solution algorithms.

Several researchers have noted the similarity between the VM allocation problem and the much-studied bin packing problem, and proposed to adopt well-known simple packing heuristics like First-Fit or Best-Fit - that are known to be approximation algorithms for bin packing - also for VM allocation. In [Mann 14], we identified several aspects that make VM allocation algorithmically harder than bin packing and assessed their impact on approximability. It turns out that some of these aspects indeed make it harder to approximate VM allocation than bin packing.

In the near future, we can expect to have processors that integrate CPU and GPU cores, sharing the last-level cache. In such a setting, the different data access patterns and rates of CPU versus GPU applications may lead to an unfair and overall suboptimal distribution of the shared cache. In order to prevent this, we devised an algorithm [Mann 15] that partitions the cache between CPU and GPU to maximize the estimated overall system performance.

Building on and extending our earlier work to formalize different flavors of the VM allocation problem, [Mann 16] introduces a taxonomy and notational system for categorizing the different versions of the problem. The notational system is defined on the basis of the well-known alpha | beta | gamma notation used for scheduling problems, but is more complicated so as to accommodate the many aspects that influence VM allocation.

Abstraction of paths, related to anycast routing

[Katona 1, 3] obtained various results in the proper generalization of the concept of paths in hypergraphs, with special emphasis on algorithms finding of shortest paths. Observe that even the number of edges in the hypertrees depends on the proper generalization, see also [Szabo, 2], where first we give a proof of the sharpness of the upper bound on the edge-number of k-uniform hypertrees. We then make an improvement of the upper bound on the edge-number of 2-hypertrees and show an interesting, new construction for 4-uniform 2-hypertrees. Furthermore, we prove upper and lower bounds on the number of edges of edge-minimal and edge-maximal hypertrees.

Related questions for structures, more general than graphs

There is a conjecture that if the union of graphic matroids is not graphic then it is nonbinary. If there are two matroids and the first one can be drawn as a graph with two points, then a necessary and sufficient condition is given for the other matroid to ensure the graphicity of the union. A similar case have proved where the first matroid is a circuit with loops and bridges. The two conditions can be rephrased by one so that it is true for both cases. This condition is sufficient for the graphicity of the union of any two graphic matroids, and it can be verified in polynomial time [Csehi 1].

Similar questions can be posed for subclasses of the class of graphic matroids if, say, their union with any (not necessarily graphic) matroid is either graphic or nonbinary. Such results have been presented in [Csehi 2].

Further matroid results were found for the voltage-current symmetries of electric networks containing linear multiports [Recski].

Using game-theoretical tools for measuring and increasing security has become very common. In [Szeszlér 4] a two-player, zero sum game is defined on matroids that contains as special cases a range of formerly known security games. The paper then derives a minimax formula for the Nash-equilibrium value of the game which generalizes the corresponding results for the known special cases. Furthermore, it gives a strongly polynomial algorithm for computing the Nash-equilibrium value of the game as well as optimum mixed strategies for both players. Finally, a further generalization of the game for the intersection of two matroids is also considered and applied to define and efficiently compute a new security metric on digraphs.

Part 3 (Scalable Data Center Applications)

In [Babarczi 2] we developed new addressing scheme for multi-cast. It is based on bloom filters which supports simple and fast lookup at routers.

Pebbling and rubbling, related to complex job scheduling

[Katona 2, 4] worked on questions of rubbling numbers of graphs. Rubbling is an extension of pebbling, which is now a fairly known notion. With Sieben, they gave an upper bound for the rubbling number of n-vertex, diameter d graphs, and estimates for the maximum rubbling number of diameter 2 graphs, a sharp upper bound for the optimal rubbling number, and sharp upper and lower bounds in terms of the diameter. With Papp they gave a formula for the optimal rubbling number of Ladders, Prisms and Möbius-ladders. They also improved an earlier upper bound by Czygrinow on the optimal pebbling number in graphs with given minimum degree.

In [Katona 7] the authors determined the optimal pebbling number of various stair-like graphs, and gave interesting upper and lower bounds of the optimal pebbling number of large grids.

[Katona 6] was submitted on epidemic propagation in hypergraphs. In this paper the authors suggest a model where human interaction is represented with a hypergraph instead of the usual simple graph. This makes it possible to have more precise simulations of epidemic propagation.

Part 4 (Algorithms and Complexity in the Cloud)

Typical-case complexity of combinatorial optimization problems.

Continuing our previous research on graph coloring, we investigated the average-case complexity of an exact algorithm for deciding k-colorability of sparse graphs [Mann 1]. We established how the complexity depends on the asymptotic behavior of the graphs' density; in particular, the algorithm has polynomial average-case complexity if the density tends to zero sufficiently slowly.

Smart exact algorithms for NP-hard problems often have highly unpredictable runtimes, and - contrary to intuition - bigger problem instances are sometimes solved faster than small ones. In [Mann, 2], we showed that the compressed size of problem instances is a better indication of complexity than their size. Moreover, we devised an algorithm that compresses graphs in such a way that the resulting compressed size has higher predictive power on the problem instance's complexity than the results from existing compression routines.

We analyzed the typical-case complexity of the Boolean satisfiability (SAT) problem using data from SAT Competition 2013, in which 93 solvers were tested on a large and diverse set of problem instances, with a total of 100,000 hours of CPU time. [Mann 3]. Our analysis uncovered interesting patterns concerning the problem instances' statistical properties and their complexity, for example a surprising negative correlation between problem instances' size and complexity in the case of application benchmarks.

Partitioning a Boolean formula into independent sub-formulae is a natural approach to solving the Boolean satisfiability problem. Although there are multiple techniques based on hypergraph partitioning for this purpose, it is not clear which one works best for typical Boolean formulae. In [Mann 4], we compared several methods empirically. Unfortunately, we found that none of the investigated methods works well for all types of formulae. On the positive side, we gained insight based on which a good partitioning method can be selected for a given problem instance.

Backtrack-style exact algorithms are often accelerated by means of frequent restarts in order to abandon unfruitful parts of the search space in favor of more promising regions. In [Mann 5] we devised a more sophisticated approach for the same goal, by using best-first-search to quickly move between different parts of the search space, always focusing on the most promising part. Our empirical evaluation on constraint satisfaction problems showed that our approach outperforms the usual method of frequent restarts.

We also adapted our best-first-search approach to the Boolean satisfiability problem and built it into a state-of-the-art SAT solver [Mann 6]. The adaptation was not straight-forward, in particular because of the highly complex data structures and the sophisticated learning mechanism used in the SAT solver. Also the conclusions are different: in this case, best-first-search was not better than restarting; however, a combination of the two approaches outperforms both.

Parameterized complexity:

[Schlotter 1] studies the computational complexity of the problem of making a graph Eulerian (that is, connected and with all vertices having even degree) by deletions, where the number of deletions cannot exceed a given bound. The results completely classify the parameterized complexity of various versions dealing with undirected or directed graphs, vertex or edge deletions, with or without the requirement of connectivity, etc. Of particular interest is a randomized FPT algorithm for making an undirected graph Eulerian by deleting the minimum number of edges, based on a novel application of the colour coding technique.

[Schlotter 2] studies the Spare Capacity Allocation problem arising in optical networks that use shared mesh restoration scheme. The authors focus on the situation where restoration paths are selected simultaneously for a group of demands in order to minimize the total cost. To analyze computational complexity of this problem in detail, they introduce the Multicost Steiner Subgraph problem, and investigate its parameterized complexity with respect to various parameters.

In [Schlotter 3] we investigate both classic and parameterized computational complexity of electoral campaign management under certain approval-like voting rules, namely the rules SP-AV, Bucklin, and Fallback. We focus on two methods that can be used to promote a given candidate: asking voters to move this candidate upwards in their preference order or asking them to change the number of candidates they approve of. We show that finding an optimal campaign management strategy of the first type is easy for both Bucklin and Fallback. In contrast, the second method is computationally hard even if the degree to which we need to affect the votes is small.

The sports elimination problem asks whether a team participating in a competition still has a chance to win, given the current standings and the remaining matches to be played among the teams. In [Schlotter 3, 4] we investigate the complexity of this problem in detail, using a multivariate approach to examine how various parameters of the graph underlying the input instance (such as the maximum degree, the feedback vertex/edge number, and different width parameters) influence the computational tractability. We obtain several efficient algorithms, as well as certain hardness results.

Data mining:

The tick data decomposition problem is an interesting combinatorial opimization problem that originates from the storage of financial tick data, however, solutions for the problem may be relevant for the storage of data from various other domains as well. In [Buza 1] we proposed a lower bound of the storage size that allowed to substantially speed up our previous algorithm, SOHAC, while the new algorithm (QuickSOHAC) produces exactly the same results as its "basic" variant (SOHAC). In particular, in our experiments on real tick data, we achieved 4-6-fold speedup compared to the "basic" variant of the algorithm. Therefore, on the tick data decomposition problem, our algorithm not only produced better results than standard clustering algorithms in terms of the resulting storage size, but, QuickSOHAC outperformed standard clustering algorithms in terms of runtime as well. Additionally, we showed that the decomposition of a tick data table can be combined with standard compression techniques, such as GZIP. When we combined our approach with GZIP, we achieved higher compression than in case of using GZIP alone which may be interpreted in the way that these results indicate that our approach may be able to detect patterns that are either not detected or not used by GZIP. The paper appeared in the ESWA journal which achieved the first position in Google Scholar's ranking of artificial intelligence journals:
http://scholar.google.com/citations?view_op=top_venues&hl=en&vq=eng_artificialintelligence
We discussed three further open questions related to the tick data decomposition problem at the Summit240 conference [Buza 4].

Hubness is an iteresting property of nearest neighbor graphs and it is relevant to classification and clustering of high-dimensional data. In [Buza 2], we described this phenomenon and surveyed hubness-aware classifiers and extended them to the classification of time-series which is the common denominator in various automated recognition tasks, such as speech or handwriting recognition.

We constructed time series of language usage in blogs and financial tweets and presented our initial results of the analysis of these time series in [Buza 3]. Language usage metrics took only the syntax into account, but not the semantics of the text. In the light of this, it is interesting that the time series which has been found to be the most anomalous in terms of language usage metric belonged to a blog which was even semantically an "outlier" (i.e., it was strange).

[Búza 5] discussed an interesting property of nearest neighbor graphs and its implications to various machine learning problems, such as classification, instance selection and clustering. The paper surveyed hubness-aware classifiers and aimed to identify interesting research directions in the domain of hubness-aware machine learning.

[Búza 6] developed a new link prediction algorithm for bipartite graphs. The core contribution is that the algorithm takes cardinality constraints into account. We applied this algorithm for the item recommendation problem known from the domain of e-commerce. Our results show that taking cardinality constraints into account indeed improves recommendation quality. In our future work, we aim to apply this algorithm to further link prediction problems, such as the drug-target interaction prediction problem.

The spectra of the modularity matrix comes up in social network analysis, and also has connection to statistics. In [Friedl 1] we give a sufficient condition for a weighted, and a sufficient and necessary condition for an unweighted graph to have at least one positive eigenvalue in its modularity or normalized modularity spectrum, which guarantees a community structure with more than one cluster. This property has implications for the isoperimetric inequality, the symmetric maximal correlation, and the Newman–Girvan modularity.

Further algorithmic results:

In [Kiss 5] we propose a system for automatic sensor registration and real-time feature level fusion by using visible-light, thermal and depth imageries. Our approach utilizes the vertical plane homography and its transformation in depth. An optimal transformation can be provided in parameter space where the corresponding blobs in different views have adequate overlapping parts. Experiments show that our approach provides real-time performance in ad-hoc and partly unreliable sensor configurations as well.

[Kiss 6] is about how can we find possible fault subsystems of an unknown computer system and detect possible errors in it. Our aim is to find a smaller part of an industrial partner's system on what he should run an error fixing algorithm in order to save time and energy by decreasing the number of nodes to inspect.

[Kiss 7] addresses two main issues of smart camera systems. On the one hand real-time processing of registering in different depth of different views is our aim and on the other hand we made the measurement in depth robust by using a master (depth) sensor in the fusion. In the paper we propose a system for automatic sensor registration and real-time feature level fusion by using visible-light, thermal and depth imageries.

[Kiss 8] is about how can we register the corresponding elements in a multi-camera system, and how can we find a homography between the image planes in real time. So we can register a moving object in the images of different cameras based on the depth information.

Viamontes et al. suggested the Quantum Information Decision Diagram (QuIDD) to use in classical simulations of quantum algorithms. In the simulation of several (but not all) quantum algorithms this data structure allows to compress the necessary space from exponential to polynomial size. In [Friedl 2, 3] we suggest further improvement and analyse in detail its behavior on Grover’s search algorithm.

Steganography is closely related to cryptography, but its task is very different: while cryptography aims at hiding the content of a message, steganography aims at hiding the very existence of the (possibly encoded) message. The basis of a number of widespread steganographic methods is to use some kind of a cover media and modify certain bits in it such that modified media is undistinguishable to the naked eye from the original one. The security of various steganographic methods is often mesured via game-theoretic tools. The paper [Szeszlér 3] focuses on a game-theoretical model formerly introduced in the literature for measuring the security of content-adaptive steganography. While it was known that the model is solvable in polynomial time via linear programming, it is shown in this paper that it is actually solvable much more efficiently, in strongly polynomial time. This opens up the possibility of applying the model on problem instances with a size corresponding to real-life applications.

Further combinatorial results

Csikvári, Gyarmati and Sárközy asked whether there exist Ramsey type theorems for the equations a+b=cd and ab+1=cd in Z_m for large enough m. In [Pach 1] we proved that for any r-coloring of Z_m the more general equation a_1+...+a_n=cd has a nontrivial monochromatic solution.

In [Pach 2] the so-called rotations are introduced for finite posets, which can be seen as the poset counterpart of Seidel-switch for finite graphs. We analyze some of their combinatorial properties, and investigate, in particular, the question when two finite posets are rotation equivalent. Moreover, we give an explicit combinatorial construction of a rotation of the random poset whose image is again isomorphic to the random poset.

In [Pach 3] the logarithm of the number of non-isomorphic rooted trees of depth k>3 with n vertices is determined asymptotically.

Let G_k(n) denote the maximal size of a subset of {1,2, ..., n} in which the equation a_1a_2... a_k=b_1b_2...b_k does not have a solution consisting of distinct elements of this set. In [Pach 4, 5] the order of magnitude of G_k(n) is determined, and several estimates are proved for the "error terms".

Simon's congruence relates the words having the same subwords of length at most k. In [Pach 6] a normal form is presented for the equivalence classes in the case k=4.

Strict group testing is the problem to identify up to d defectives out of n elements, by testing subsets in stages for the presence of defectives, where the searcher must also verify that at most d defectives are present. In [Wiener 2] we start building a combinatorial theory of strict group testing and compute the exact number of tests necessary and sufficient for many values of n, d, and the number of stages s. Besides other combinatorial tools we generalize d-disjunct matrices to any candidate hypergraph, and we reveal connections to the set basis problem and communication complexity.

In [Soltész 2] we improve the upper bound on Simonyi's conjecture. This improves the theoretical upper bound on the rate of communication using WUM codes in the setting where both the encoder and the decoder is uninformed about the previous state of the memory.

References

[Babarczi 1] J. Tapolcai, Pin-Han Ho, P. Babarczi, L. Rónyai, "Internet Optical Infrastructure - Issues on Monitoring and Failure Restoration", Springer, pp. 1-212, 2015. [ISBN 978-1-4614-7737-2]

[Babarczi 2] J. Tapolcai, J. Biro, P. Babarczi, A. Gulyás, Z. Heszberger, D. Trossen, "Optimal False-Positive-Free Bloom Filter Design for Scalable Multicast Forwarding", IEEE/ACM Transactions on Networking, 23, 10, 2014. [impact factor 1.986]

[Babarczi 3] J. Tapolcai, Pin-Han Ho, P. Babarczi, L. Rónyai, "Neighborhood Failure Localization in All-Optical Networks via Monitoring Trails", IEEE/ACM Transactions on Networking, 1, 1-12, 2015. [impact factor 1.986]

[Babarczi 4] A. Pasic, J. Tapolcai, P. Babarczi, E. Bérczi-Kovács, Z. Király, and L. Rónyai, "Survivable routing meets diversity coding," in **IFIP Networking**, Toulouse, France, 2015, pp. 1-9. acceptance rate 24%

[Babarczi 5] P. Babarczi, A. Pasic, J. Tapolcai, F. Németh, and B. Ladóczki, "Instantaneous recovery of unicast connections in transport networks: routing versus coding," **Elsevier Computer Networks**, Special Issue on Robust and Fault-tolerant Communication Networks, 2015. impact factor 1.282

[Babarczi 6] A. Pasic and P. Babarczi, "Delay aware survivable routing with network coding in software defined networks," in Proc. Reliable Networks Design and Modeling (**RNDM**), Munich, Germany, 2015, pp. 1-7.

[Babarczi 7] Tapolcai, P. Ho, P. Babarczi, and L. Rónyai, "Neighborhood Failure Localization in All-Optical Networks via Monitoring Trails," in **IEEE/ACM Transactions on Networking**, vol. PP, iss. 99, pp. 1-1, 2015. accepted.

[Buza 1] Krisztian Buza, Gabor Nagy, Alexandros Nanopoulos: Storage-Optimizing Clustering Algorithms for High-Dimensional Tick Data, Expert Systems with Applications, 41 pp. 4148-4157. (2014), impact factor: 1.854

[Buza 2] Nenad Tomasev, Krisztian Buza, Kristóf Marussy, Piroska B. Kis: Hubness-aware Classification, Instance Selection and Feature Construction: Survey and Extensions to Time-Series, In: U. Stańczyk, L. Jain (eds.), Feature selection for data and pattern recognition (tentative title), to be published by Springer-Verlag, book chapter, 28 pages

[Buza 3] Krisztian Buza, Gabor I. Nagy, Alexandros Nanopoulos: Trend analysis and anomaly detection in time series of language usage, VI. Dubrovnik Conference on Cognitive Science (DUCOG), 2014, conference abstract and poster

[Buza 4] Krisztian Buza, Gabor I. Nagy, Alexandros Nanopoulos: Three Open Questions related to the Tick Data Decomposition Problem, Summit240 Conference, 2014 conference abstract

[Búza 5] K. Buza (2015): Hubness: An Interesting Property of Nearest Neighbor Graphs and its Impact on Classification, 9th Japanese-Hungarian Symposium on Discrete Mathematics and Its Applications, Fukuoka, 2015, pp. 1-8.

[Búza 6] K. Marussy, L. Peška, K. Buza (2015): Recommendations of Unique Items Based on Bipartite Graphs, 9th Japanese-Hungarian Symposium on Discrete Mathematics and Its Applications, Fukuoka, 2015, pp. 439-448.

[Csehi 1] Csongor Gy. Csehi, András Recski: The graphicity of the union of graphic matroids, European Journal of Combinatorics 50 (2015) 38-47.

[Csehi 2] Csongor Gy. Csehi, András Recski: Matroid Union – Graphic? Binary? Neither?, 9th International colloquium on graph theory and combinatorics, 2014, Grenoble, Franciaország

[Csehi 3] Csongor Gy. Csehi, András Recski: Some new subclasses of graphic matroids, related to the union operation, 9th Japanese-Hungarian Symposium on Discrete Mathematics and Its Applications, Fukuoka, 2015, pp. 83-90.

[Friedl 1] Bolla M, Bullins B, Chaturapruek S, Chen S, Friedl, K: Spectral properties of modularity matrices, Linear Algebra and its Applications 473: pp. 359-376. (2015)

[Friedl 2] Friedl, K, Kabódi, L: An idea to improve QuIDD based quantum simulations, Proc. of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and its Applications, Fukuoka, Japan, pp. 360-368, 2015.

[Friedl 3] Friedl, K, Kabódi, L: An idea to improve QuIDD based quantum simulations, Periodica Polytechnica Electrical Engineering and Computer Science, 59(2), pp. 48-55. (2015)

[Gulyás 1] A. Csoma, B. Sonkoly, L. Csikor, F. Németh, A. Gulyás, W. Tavernier and S. Sahhaf, "ESCAPE: Extensible Service ChAin Prototyping Environment using Mininet, Click, NETCONF and POX", In Proc. ACM SIGCOMM Demo, Chicago, IL, USA, August 17-22, 2014. ACM Press, 125-126.

[Gulyás 2] B. Sonkoly, F. Németh, L. Csikor, L. Gulyás, A. Gulyás, "SDN based Testbeds for Evaluating and Promoting Multipath TCP", IEEE ICC 2014 Sydney Australia, pp. 3044-3050.

[Katona 1] Katona Gyula Y., Paths and cycles in hypergraphs, Graph Theory Conference in honor of Yoshimi Egawa on the occasion of his 60th birthday, 2014, Tokyo, Japan

[Katona 2] Katona Gyula Y, Papp László; The Optimal Rubbling Number of Ladders, Prisms and Möbius-ladders, 9th International colloquium on graph theory and combinatorics, 2014, Grenoble, Franciaország

[Katona 3] Katona Gyula Y, Extension of paths and cycles for hypergraphs, Electronic Notes in Discrete Mathematics 45: pp. 3-7. (2014)

[Katona 4] Katona Gyula Y., Sieben N., Bounds on the Rubbling and Optimal Rubbling Numbers of Graphs, Graphs and Combinatorics 29: (3) pp. 535-551. (2013)

[Katona 5] Katona Gyula Y., M. Faghani, A.R. Ashrafi, Centrosymmetric graph and a lower bound for graphs energy of fullerens, Discussiones Mathematicae Graph Theory, 2014 doi:10.7151/dmgt.1761

[Katona 6] Á. Bodó, G. Y. Katona, P. L. Simon, SIS epidemic propagation on hypergraphs, submitted to Bulletin of Mathematical Biology

[Katona 7] E. Győri; G. Y. Katona; L. F. Papp, Optimal pebbling of grids, In: 13th Cologne-Twente Workshop on Graphs & Combinatorial Optimization. Isztambul, Törökország, 2015.05.26-2015.05.28.pp. 156-162.

[Katona 8] G. Y Katona; L F. Papp; Upper Bound on the Optimal Rubbling Number in graphs with given minimum degree, In: Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications. Fukuoka, Japán, 2015. pp. 313-317.

[Katona 9] G. Y Katona; L. F Papp; Optimal pebbling of grids, In: Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications. Fukuoka, Japán, 2015. pp. 307-311.

[Katona 10] G.Y Katona; L. F. Papp; Upper Bound on the Optimal Rubbling Number in graphs with given minimum degree, submitted to Discrete Applied Mathematics

[Kiss 1] Attila Kiss: "3-Dimensional Gamma Routing Problem in VLSI Design", under review.

[Kiss 2] Attila Kiss, András Recski: "Polynomial Time Algorithms for the 3-Dimensional VLSI Routing in the Cube", Summit 240 Conference, Budapest, Hungary, 2014.07.07-11.

[Kiss 3] Attila Kiss, András Recski: "Universal Spacings for the 3-Dimensional VLSI Routing in the Cube", IX. International Colloquium on Graph Theory and Combinatorics, Grenoble, France, 2014.06.30-07.04.

[Kiss 4] Attila Kiss: "Space Decreasing Techniques for 3D VLSI Routing", Seventh Cracow Conference On Graph Theory, Rytro, Poland, 2014

[Kiss 5] László Havasi, Attila Kiss, László Spórás, Tamás Szirányi: "Online Multimodal Sensor Fusion with Fault Tolerance", under review, 2014

[Kiss 6] Attila Kiss, Anna Mándli, Tamás Szirányi: "Unsupervised Error Estimation of Autonomous Agent Networks", Seventh Cracow Conference On Graph Theory, Rytro, Poland, 2014

[Kiss 7] László Havasi, Attila Kiss, László Spórás, Tamás Szirányi: "Sensor Auto-Registration and Real-Time Fusion with Blob Alignment for Multimodal Image Sources", under review, 2014

[Kiss 8] László Havasi, Attila Kiss, László Spórás, Tamás Szirányi: "Calibrationless Sensor Fusion Using Linear Optimization for depth Matching", Combinatorial Image Analysis, Springer International Publishing, 2014. 158-170.

[Kiss 9] Attila Kiss, András Recski: A spacing-volume tradeoff in 3-dimensional VLSI routing. Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications. Fukuoka, Japán, 2015. pp. 285-290.

[Kőrösi 1] A. Kőrösi, J. Tapolcai, Bence Mihálka, Gábor Mészáros, G. Rétvári, "Compressing IP Forwarding Tables: Realizing Information-theoretical Space Bounds and Fast Lookups Simultaneously", In Proc. IEEE ICNP, 2014. pp. 332-343. [acceptance rate 20%].

[Kőrösi 2] B. Mihálka, G. Rétvári, A. Kőrösi, "Compressing Virtual Forwarding Information Bases Using Trie-folding Algorithm", IFIP EUNICE, Rennes, France, 2014. Springer Lecture Notes in Computer Science; 8846, pp. 121-133.

[Kőrösi 3] M. Zubor, A. Kőrösi, A. Gulyás, G. Rétvári, "On the Computational Complexity of Policy Routing", IFIP EUNICE, Rennes, France, 2014. Springer Lecture Notes in Computer Science; 8846, pp. 202-214.

[Kőrösi 4] G. Rétvári, D. Szabó, A. Gulyás, A. Kőrösi, and J. Tapolcai, "An information-theoretic approach to routing scalability," in Proceedings of the 13th ACM Workshop on Hot Topics in Networks (**HotNETS**), 2014, p. 2

[Mann 1] Zoltán Ádám Mann, Anikó Szajkó: Average-case complexity of backtrack search for coloring sparse random graphs. Journal of Computer and System Sciences, volume 79, number 8, pages 1287-1301, Elsevier, 2013. IF=1.091.

[Mann, 2] Zoltán Ádám Mann, Pál András Papp: Predicting algorithmic complexity through structure analysis and compression. Applied Soft Computing, volume 13, number 8, pages 3582-3596, Elsevier, 2013. IF=2.679.

[Mann 3] Zoltán Ádám Mann: Typical-case complexity and the SAT competitions. Proceedings of the 5th Pragmatics of SAT Workshop (POS-14), EasyChair Proceedings in Computing, volume 27, pages 72-87, 2014

[Mann 4] Zoltán Ádám Mann, Pál András Papp: Formula partitioning revisited. Proceedings of the 5th Pragmatics of SAT Workshop (POS-14), EasyChair Proceedings in Computing, volume 27, pages 41-56, 2014

[Mann 5] Zoltán Ádám Mann, Tamás Szép: Accelerating backtrack search with a best-first-search strategy. International Journal of Applied Mathematics and Computer Science, volume 24, number 4, pages 901-916, 2014. IF=1.39

[Mann 6] Dávid Bartók, Zoltán Ádám Mann: Accelerating SAT solving with best-first-search. Proceedings of the 15th IEEE International Symposium on Computational Intelligence and Informatics, pages 43-48, 2014.

[Mann 7] Zoltán Ádám Mann: Allocation of virtual machines in cloud data centers - a survey of problem models and optimization algorithms. ACM Computing Surveys, volume 48, issue 1, 2015. IF=3.373

[Mann 8] Zoltán Ádám Mann: Rigorous results on the effectiveness of some heuristics for the consolidation of virtual machines in a cloud data center. Future Generation Computer Systems, volume 51, pages 1-6, 2015. IF=2.786

[Mann 9] Imre Kocsis, Zoltán Ádám Mann, Dávid Zilahi: Optimal deployment for critical applications in Infrastructure as a Service. 3rd International IBM Cloud Academy Conference (ICACON 2015), 2015.

[Mann 10] Ehsan Ahvar, Shohreh Ahvar, Noel Crespi, Joaquin Garcia-Alfaro, Zoltán Ádám Mann: NACER: a Network-Aware Cost-Efficient Resource allocation method for processing-intensive tasks in distributed clouds. Accepted for the 14th IEEE International Symposium on Network Computing and Applications, 2015.

[Mann 11] Imre Kocsis, Zoltán Ádám Mann, Dávid Zilahi: Optimal deployment for critical applications in Infrastructure as a Service. Submitted for peer review.

[Mann 12] Zoltán Ádám Mann: Multicore virtual machine placement in cloud data centers. Submitted for peer review

[Mann 13] Zoltán Ádám Mann: Modeling the virtual machine allocation problem. Proceedings of the International Conference on Mathematical Methods, Mathematical Models and Simulation in Science and Engineering, pages 102-106, 2015.

[Mann 14] Zoltán Ádám Mann: Approximability of virtual machine allocation: much harder than bin packing. Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications, pages 21-30, 2015.

[Mann 15] Lázár Jani, Zoltán Ádám Mann: Cache optimization for CPU-GPU heterogeneous processors. American Journal of Algorithms and Computing, volume 2, number 1, pages 18-31, 2015.

[Mann 16] Zoltán Ádám Mann: A taxonomy for the virtual machine allocation problem. International Journal of Mathematical Models and Methods in Applied Sciences, volume 9, pages 269-276, 2015.

[Mann 17] Zoltán Ádám Mann: Complexity of coloring random graphs: zooming in on the hardest part. Submitted for peer review.

[Pach 1] Pach P P: Ramsey type results on the solvability of certain equations in Z_m, Integers, 13, 2013

[Pach 2] Pach P P, Pinsker M, Pongrácz A, Szabó Cs: A new operation on partially ordered sets, Journal of Combinatorial Theory Series A Structure Design and Applications 120:(7) 1450-1462., 2013

[Pach 3] Pach P P, Pluhár G, Pongrácz A, Szabó Cs: The number of rooted trees of given depth, Electron. J. Comb. 20:(2) P38, 2013

[Pach 4] Pach P P: Generalized multiplicative Sidon sets, J. Number Theory 157 (2015), 507-529.

[Pach 5] Pach P P: Generalized multiplicative Sidon-sequences, 9th International Colloquium on Graph Theory and Combinatorics, Grenoble, 2014 (abstract)

[Pach 6] Pach P P: Solving Equations under Simon's Congruence, Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications (2015), 201-206.

[Recski] András Recski, Matroid duality and voltage-current symmetries, Proc. 8th Japanese-Hungarian Symposium on Discrete Mathematics and its Applications, 2013, 419-425.

[Rétvári 1] M. Nagy, J. Tapolcai, G. Retvari, "On the Design of Resilient IP Overlays", In Proc. International Workshop on Design Of Reliable Communication Networks (DRCN), Ghent, Belgium, 2014, pp. 1-8.

[Rétvári 2] A. Gulyás, G. Rétvári, Z. Heszberger, R. Agarwal, "On the Scalability of Routing with Policies", IEEE/ACM Transactions on Networking, 23, 9, 2014. [impact factor 1.986]

[Rétvári 3] A. Majdán, G. Rétvári, J. Tapolcai, "Development and Performance Evaluation of Fast Combinatorial Unranking Implementations", IFIP EUNICE, Rennes, France, 2014, Lecture Notes in Computer Science Vol. 8846, 97-108.

[Rétvári 4] J. Tapolcai, G. Rétvári, P. Babarczi, E. Bérczi-Kovács, P. Kristóf, and G. Enyedi, "Scalable and efficient multipath routing: complexity and algorithms," in IEEE International Conference on Network Protocols (**ICNP**), San Francisco, CA, USA, 2015, pp. 1-10, acceptance rate 18%.

[Schlotter 1] Marek Cygan, Dániel Marx, Marcin Pilipczuk, Michał Pilipczuk, Ildikó Schlotter: Parameterized complexity of Eulerian deletion problems, Algorithmica, volume 68, issue 1, pp. 41-61, 2014.

[Schlotter 2] Tibor Jordán, Ildikó Schlotter: Parameterized complexity of Spare Capacity Allocation and the Multicost Steiner Subgraph problem, Journal of Discrete Algorithms 30, 29-44, 2015.

[Schlotter 3] I. Schlotter, P. Faliszewski, E. Elkind: Campaign management under approval-driven voting, to appear in *Algorithmica*.

[Schlotter 4] K. Cechlárová, E. Potpinková, I. Schlotter: Refining the complexity of the sports elimination problem, to appear in *Discrete Applied Mathematics*.

[Schlotter 5] I. Schlotter, Computational Social Choice: Theory and Applications, Dagstuhl Seminar 15241.

[Soltész 1] D. Soltész: On the 1-switch conjecture in the hypercube, Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications. Fukuoka, Japán, 2015. pp. 123-125.

[Soltész 2] D. Soltész: New bounds on Simonyi's conjecture, submitted

[Szabó 1] Péter G. N. Szabó, Symmetric distance formula in kantor spaces and the radius of the circumscribed sphere of affinely independent set of points, Periodica Polytechnica, 2014, accepted, doi: PPee.2094

[Szabó 2] Péter G. N. Szabó, Bounds on the number of edges of edge-minimal, edge-maximal and l-hypertrees, Discussiones Mathematicae Graph Theory, accepted

[Szeszlér 1] L. Buttyán, A. Laszka, D. Szeszlér: A Minimum Cost Source Location Problem for Wireless Sensor Networks, Proceedings of the 8th Japanese-Hungarian Symposium on Discrete Mathematics and Its Applications, Veszprém, Hungary, 2013, pages 79-88.

[Szeszlér 2] A. Laszka, L. Buttyán, D. Szeszlér: Designing robust network topologies for wireless sensor networks in adversarial environments, Pervasive and Mobile Computing, Volume 9, Issue 4, 2013, pages 546-563.

[Szeszlér 3] A. Laszka, D. Szeszlér: Hide and Seek in Digital Communication: The Steganography Game, Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications, Fukuoka, Japan, pp. 126-136 (2015).

[Szeszlér 4] D. Szeszlér: Security Games on Matroids, *submitted*

[Tapolcai 1] J. Tapolcai, L. Rónyai, É. Hosszu, Pin-Han Ho, S. Subramaniam, "Signaling Free Localization of Node Failures in All-Optical Networks", In Proc. IEEE INFOCOM, Toronto, Canada, pp. 1860-1868, 2014.

[Tapolcai 2] P. Babarczi, J. Tapolcai, L. Ronyai, M. Medard, "Resilient Flow Decomposition of Unicast Connections with Network Coding", In Proc. IEEE International Symposium on Information Theory (ISIT), pp. 116-120, Honolulu, HI, USA, 2014

[Tapolcai 3] M.L. Ali, Pin-Han Ho, J. Tapolcai, S. Subramaniam, "Multi-Link Failure Localization via Monitoring Bursts", IEEE/OSA Journal of Optical Communications and Networking (JOCN), 2014. 6, 952-964. [impact factor 1.547]

[Tapolcai 4] É. Hosszu, C. Fragouli, and J. Tapolcai, "Combinatorial error detection in linear encoders," in Proc. High Performance Switching and Routing (**HPSR**), Budapest, Hungary, 2015. **Best Paper**

[Tapolcai 5] L. Gyimóthi and J. Tapolcai, "A heuristic algorithm for Network-Wide local unambiguous node failure localization," in Proc. High Performance Switching and Routing (**HPSR**), Budapest, Hungary, 2015.

[Tapolcai 6] L. Gyimóthi, É. Hosszu, and J. Tapolcai, "Constructions for unambiguous node failure localization in grid topologies," in Proc. Reliable Networks Design and Modeling (**RNDM**), Munich, Germany, 2015.

[Toth 1] Gábor Simonyi, Ágnes Tóth, A generalization of Witsenhausen's zero-error rate for directed graph, submitted (IEEE Transactions on Information Theory)

[Toth 2] Gábor Simonyi, Ágnes Tóth, A generalization of Witsenhausen's zero-error rate for directed graphs, IEEE International Symposium on Information Theory. 2014. pp. 2864-2868.

[Toth 3] Ágnes Tóth, On the ultimate categorical independence ratio, Journal of Combinatorial Theory Series B 108, pp. 29-39 (2014)

[Toth 4] Shinya Fujita, Michitaka Furuya, András Gyárfás, Ágnes Tóth, A Note on Covering Edge Colored Hypergraphs by Monochromatic Components, Electronic Journal of Combinatorics 21:(2), P2.33, 10 p. (2014)

[Wiener 1] G. Wiener: Leaf-critic graphs, Proc. of the 3rd Bordeaux Graph Workshop, 2014, 101-102.

[Wiener 2]: P. Damaschke, A. S. Muhammad, G. Wiener: Strict Group Testing and the Set Basis Problem, Journal of Combinatorial Theory A, 2014.

[Wiener 3] G. Wiener: On non-traceable, non-hypotraceable, arachnoid graphs, Electronic Notes in Discrete Mathematics, EUROCOMB 2015

[Wiener 4] G. Wiener: Leaf-critical and leaf-stable graphs, In: Proceedings of the 9th Hungarian-Japanese Symposium on Discrete Mathematics and Its Applications, 267-278.

[Wiener 5] D. Gerbner, B. Keszegh, D. Pálvölgyi, B. Patkós, M. Vizer, G. Wiener: Finding a majority ball with majority answers, Electronic Notes in Discrete Mathematics, EUROCOMB 2015.

[Wiener 6] D. Gerbner, B. Keszegh, D. Pálvölgyi, G. Rote, G. Wiener: Search for the end of a path in the d-dimensional grid and in other graphs, submitted.

[Wiener 7] T. Fleiner, G. Wiener: Coloring signed graphs using DFS, submitted