Abstracts of the Annual Workshop 2002

Thursday, 10/10/02

1. 8:30-9:10, **Ervin Györi**

   Triangles and Pentagons

   We present some classical and recent open and solved extremal graph theoretic problems related to triangles or pentagons including well-known ones of Erdős about pentagons in triangle-free graphs. Furthermore, we study triangle-free and pentagon-free hypergraphs, too, partly on their own interest, partly to answer some number theoretic questions.

2. 9:20-10:00, **Thomas Erlebach**

   Algorithms for Call Admission Control

   For a given set of connection requests in a communication network, call admission control is the problem of deciding which requests to accept and which to reject. Accepting a request (call) requires reserving the desired bandwidth on all links along a path from the sender to the receiver. The link capacities must not be exceeded. The objective can be to maximize the number of accepted calls or the total profit obtained from the accepted calls. The edge-disjoint paths problem and the unsplittable flow problem are special cases of call admission control. The problem can be considered in an on-line setting where the requests must be handled one by one without knowledge about future requests or in an off-line setting where all requests are known in advance. One wants to find approximation algorithms or on-line algorithms with good approximation ratios. In this talk, we will discuss known results for various problem variants, explain useful algorithmic techniques that have been applied successfully, and point to some open problems.

3. 10:30-11:00, **Sai Anand**

Call Control in Rings

A call in a communication network is a request for a path connecting two nodes using links of the network. Accepting a call yields a profit while at the same time using up resources on the links of some path connecting the nodes.

Call admission control is the problem of deciding to accept or reject calls in a given call sequence. The overall objective is to maximize the profits due to the accepted calls. The resources used up by accepted calls must not exceed those available in the network.

We study this problem in the setting of a ring, i.e. a graph consisting of a single cycle, and a priori knowledge of the call sequence. For the variation where the paths of the calls are already specified we show an optimal polynomial time algorithm for maximizing the number of accepted calls. For the case where the paths need to be chosen by the algorithm with the above objective we reach within an additive constant of 6 to an optimal algorithm.

The talk is partly based on joint work with Udo Adamy, Christoph Ambuehl and Thomas Erlebach.

4. 11:00-11:30, **Katharina Langkau**

Flow-Dependent Transit Times: The Quickest Flow Problem

Motivated by applications in road traffic control, we study flows in networks featuring special characteristics. Firstly, there are transit times on the arcs of the network which specify the amount of time it takes for flow to travel through an arc; in particular, flow values on arcs may change over time. Secondly, the transit time of an arc varies with the current amount of flow using this arc. The latter feature is crucial for various real-life applications of flows over time; yet, it dramatically increases the degree of difficulty of the resulting optimization problems.

Most problems dealing with flows over time and constant transit times can be translated to static flow problems in time-expanded networks. Using similar ideas, we introduce an alternative time-expanded network with flow-dependent transit times to which the whole algorithmic toolbox developed for static flows can be applied. Although this approach does not entirely capture the behavior of flows over time with flow-dependent transit times, we present approximation results which provide evidence of its surprising quality.

5. 11:30-12:00, **Vanessa Kääb**

Local Search in AND/OR-Networks

A standard tool to attack NP-hard problems is local search. In this case the problem is resource constrained project scheduling. An instance is given by a set of jobs with positive processing times, a directed graph describing the precedence constraints, and a set of forbidden sets representing the resource constraints. The problem is to find a feasible schedule that minimizes the project completion time, the so-called makespan. To resolve the resource conflicts a waiting job is chosen for every forbidden set, which has to wait for the completion of at least one of the other jobs in the set. This selection can be represented by an AND/OR-network. For an AND/OR-network, there exists a unique earliest start schedule which minimizes the makespan for this selection and can be computed in polynomial time. We will consider a canonical neighborhood on the set of all AND/OR-networks for a given instance of the scheduling problem. As a main result we will show that the set of feasible networks is connected with respect to the neighborhood relation, thus it is possible to find an optimum schedule by just considering feasible networks. We will also have a short discussion on search strategies in this neighborhood relation.

6. 15:30-16:00, **Alexander Hall**

Classifying Customer-Provider Relationships in the Internet

The problem of inferring customer-provider relationships in the autonomous system topology of the Internet leads to the following optimization problem: given an undirected graph G and a set P of paths in G, orient the edges of G such that as many paths as possible are valid, meaning that they do not contain an internal node with both incident edges on the path directed away from that node. The complexity of this problem was left open by Subramanian et al. ("Characterizing the Internet hierarchy from multiple vantage points," INFOCOM 2002). We show that finding an orientation that makes all paths valid (if such an orientation exists) can be done in linear time and that the maximization version of the problem is NP-hard and cannot be approximated within $1/n^{1-\varepsilon}$ for n paths unless NP=co-$\mathcal{RP}$. We present constant-factor approximation algorithms for the case where the paths have bounded length and prove that the problem remains APX-hard in this case. Finally, we report experimental results demonstrating that the approximation algorithm yields very good solutions on real data sets.

7. 16:00-16:30, **Lingsheng Shi**

Ramsey Numbers of Sparse Graphs

The Ramsey number $R(G_1, G_2)$ of two graphs G_1 and G_2 is the least integer p so that either a graph G of order p contains a copy of G_1 or its complement G^c contains a copy of G_2. In 1973, Burr and Erdős offered a total of $25 for the conjecture that there is a constant $c = c(d)$ so that $R(G, G) \leq c|V(G)|$ for all d-degenerate graphs G i.e. the Ramsey numbers grow linearly for d-degenerate graphs. I will show in the talk that the Ramsey numbers grow linearly for degenerate graphs versus some sparser graphs, arrangeable graphs and crowns for example. These imply that the Ramsey numbers grow linerly for degenerate graphs versus graphs with bounded maximum degree, planar graphs or graphs without any topological minor of a fixed clique etc.

8. 16:30-17:00, **Andrzej Dudek**

Random Maximal H-free Graphs

Given a graph H, a random maximal H-free graph is constructed by the following random greedy process. First assign to each edge of the complete graph on n vertices a birthtime which is uniformly distributed in [0.1]. At time $p = 0$ start with the empty graph and increase p gradually. Each time a new edge is born, it is included in the graph if this does not create a copy of H. The question is then how many edges such a graph will have when $p = 1$.

9. 17:30-18:00, **Ares Ribó Mor**

Locked and Unlocked Self-Touching Linkages

In the last years, there has been much progress in the study of linkages that are locked, in the sense that there exists no motion into some other configuration preserving the bar lengths and without bar crossings. Self-touching frameworks, in which multiple edges converge to geometrically overlapping configurations, are of great interest in this context, since locked linkages are often based on approximations to them.

This talk will describe some open problems in $\mathbb{R}^2$ which I am working on. The idea is to use geometric planar properties combined with techniques from rigidity theory, as first-order rigidity and equilibrium stresses.

10. 18:00-18:30, **Panos Giannopoulos**

Approximating the Maximum Area of Overlap of Unions of Discs under Translations

We study the function of the area of overlap of two unions of discs under translations and give simple approximation schemes for obtaining its maximum for the special case of unit disjoint discs.

11. 18:30-19:00, **Martin Kutz**

The Complexity of Boolean-Matrix-Root Computation

Multiplication of Boolean $0-1$-matrices is defined as ordinary matrix multiplication with $+$ and $*$ replaced by the Boolean operations OR and AND. A kth root of a Boolean $n \times n$-matrix, $k \geq 2$, is another Boolean matrix R with $R^k = A$. We show the problem of determining whether a given Boolean matrix has a kth root NP-complete for every single parameter $k \geq 2$. This solves a question that had been open for twenty years. Further, we investigate a subclass of Boolean matrices for which root finding turns out graph-isomorphism complete. This may come quite as a surprise, since all problems that are known to lie in this complexity class are more or less obviously "isomorphism problems" of certain combinatorial structures.

Friday, 10/11/02

1. 8:30-9:10, **Günter Rote**

Pursuit-Evasion Games with Imprecise Target Location and Buffer Minimization in On-Line-Scheduling

We consider a game between two persons where one person tries to chase the other, but the pursuer only knows an approximation of the true position of the fleeing person. The two players have identical constraints on their speed. It turns out that, when the speed constraints are given by a polyhedral metric, the pursuer can always remain within a constant distance of the other person.

We apply this problem to buffer minimization in an on-line scheduling problem with conflicts.

2. 9:20-10:00, **Markus Bläser**

Approximation Algorithms for Traveling Salesperson Problems

The Travelling Salesperson Problem (TSP) is a well known and fundamental problem in computer science with a lot of practical applications. Since it is NP-hard (at least most of its variants), much effort has been spent on designing good approximation algorithms for this problem.

In our talk, we will mainly discuss the following variants:

The first variant is the asymmetric TSP with triangle inequality, the most interesting variant of asymmetric Travelling Salesperson Problems.

The second variant is the TSP with distances one and two, a special case of the TSP with triangle inequality. This problem is of particular interest, since despite its simplicity, it is already APX-complete.

3. 10:30-11:00, **Tibor Szabó**

Two-Coloring with Bounded Monochromatic Components

The concept of usual graph coloring calls for a partition of the vertex set of a graph into independent sets. It is known that graphs with maximum degree d can be partitioned into $d+1$ independent sets. Alon, Ding, Oporowski and Vertigan showed that every 4-regular graph has a vertex partition into two parts such that both parts span connected components of order bounded by a constant (as opposed to 1, like in a proper coloring). They also constructed a sequence of 6-regular graphs, which do not admit such a two-partition. Here we show that 5-regular graphs *do* have a partition into two classes with bounded connected components. There are several related open questions concerning partitions into $k > 2$ parts. For example it is not known whether a 9-regular graph could be 3-partitioned such that each part spans components of size bounded by a constant. (Joint work with Penny Haxell and Gábor Tardos.)

4. 11:00-11:30, **Yoshio Okamoto**

Matroid Representation of Clique Complexes

It is known that any independence system (or an abstract simplicial complex) can be represented as the intersection of a finite number of matroids. In this work we investigate the number of matroids which we need to represent the clique complex of a graph (i.e., the family of the cliques of a graph) and characterize such numbers in terms of an associated covering problem.

Joint work with Kenji Kashiwabara and Takeaki Uno.

5. 11:30-12:00, **Hein van der Holst**

A new Polynomial Time Algorithm for Testing whether a Graph has a Linkless Embedding or not

A linkless embedding of a graph is an embedding of the graph into 3-space such that the linking number (taken modulo two) is zero for the images of each two disjoint circuits of the graph.

The first known polynomial time algorithm to test whether a graph has a linkless embedding or not follows from the Graph Minors project of Robertson and Seymour: the class of graphs that have a linkless embedding is closed under taking minors, and, hence, according to some theorems in the Graph Minors project, it can be checked in $O(|V|^3)$ time whether a graph $G = (V, E)$ has a linkless embedding or not. However, this algorithm should be viewed more as a theoretical result than as a practical result.

In this talk we shall present a different polynomial time algorithm for testing whether a graph has a linkless embedding or not, which seems to be more practical.

6. 15:30-16:00, **Julian Pfeifle**

Many Triangulated 3-Spheres

In 1988, Kalai constructed "many triangulated d-spheres": for fixed $d > 3$ and large n, the number of triangulated d-spheres on n vertices by far exceeds the number of combinatorial types of simplicial $(d+1)$-polytopes. However, for $d = 3$ Kalai's construction yields only polytopal spheres. We present a new construction that for large n produces far more simplicial 3-spheres than there are types of simplicial 4-polytopes.

7. 16:00-16:30, **Peter Csorba**

Note on the $\mathbb{Z}_2$-Index of the Join of Topological Spaces

Topological methods are proved to be very powerful in combinatorial and geometric problems. We can bound combinatorial quantities, for example the chromatic number of a graph, by the $\mathbb{Z}_2$-index of appropriate topological spaces. In order to compute the $\mathbb{Z}_2$-index of the join of two spaces we often use the following theorem:

$$\max(\operatorname{ind}(X), \operatorname{ind}(Y)) \leq \operatorname{ind}(X * Y) \leq \operatorname{ind}(X) + \operatorname{ind}(Y) + 1.$$

I will present some examples showing that these estimates are tight.

8. 16:30-17:00, **Arnold Waßmer**

A Quantified Version of the Borsuk-Ulam Theorem

The Borsuk-Ulam theorem states that certain maps between spheres cannot be continuous. We can quantify this discontinuity adding some elementary linear algebra.

9. 17:30-18:00, **Bettina Speckmann**

Convexity Minimizes Pseudo-Triangulations

A pseudo-triangle is a planar polygon with exactly three convex vertices, called corners. Three reflex chains of edges join the corners. Let S be a set of n points in general position in the plane. A pseudo-triangulation for S is a partition of the convex hull of S into pseudo-triangles whose vertex set is S. A pseudo-triangulation is called minimum if it consists of exactly $n-2$ pseudo-triangles (and $2n-3$ edges), the minimum possible. Each vertex of a minimum pseudo-triangulation is pointed, that is, its incident edges span a convex angle.

For standard triangulations it is not known which sets of points have the fewest or the most triangulations. In contrast, we show that sets of points in convex position minimize the number of minimum pseudo-triangulations.

Joint work with Oswin Aichholzer, Franz Aurenhammer, and Hannes Krasser.

10. 18:00-18:30, **Andreas Paffenholz**

A Series of 2-Simple, 2-Simplicial 4-Polytopes

D. Eppstein, G. Kuperberg and G. M. Ziegler recently presented a method for the construction of 2-simplicial, 2-simple 4-polytopes (the "E-construction"). Their method produces such polytopes starting from a simplicial polytope having its edges tangent to the unit sphere. Thus most of the polytopes they produce are quite rigid and cannot be realized with rational coordinates. Families of 2-simplicial, 2-simple polytopes are interesting for the problem of classifying possible flag vectors of 4-polytopes. In my talk I will present a generalization of the E-construction that drops the edge-tangency requirement and give an infinite family of rational 2-simplicial, 2-simple polytopes with many degrees of freedom.

11. 18:30-19:00, **Ingo Schurr**

How structured are Unique Sink Orientations of Cubes?

Unique Sink Orientations of cubes seem to be a promising framework for many combinatorial problems, among them Linear Programming. Their advantage is that they come with a nice structure, which may help to design and understand good optimization algorithms.

I will give an overview of the facts we know about this structure. I will talk about how to construct or decompose unique sink orientations, how algebra may or may not help, how random unique sink orientations can be constructed and how they may look like.

Saturday, 10/12/02

1. 8:30-9:10, **Ralph-Hardo Schulz**

Constant Weight Codes, Divisible Designs and Finite Laguerre Geometries

Constant weight codes are codes over the alphabet $A = \{1, 2, \ldots, s\}$ with words of equal length and equal Hamming weight k (number of non-zero entries).

One can get codes of this kind by using divisible $t-$designs. These are incidence structures whose point set is divided into classes of equal size and whose block set consists of $k-$sets of points such that, with any transversal t-set of points, there is incident a constant number λ_t of blocks.

In our talk, we want to describe a construction of divisible 3-designs from finite Laguerre geometries; these are chain geometries on the point set of the projective line over the (local) ring of dual numbers over a finite field GF(q). We use the fact that the automorphism group of such a geometry operates transitively on transversal point triples.

2. 10:00-10:30, **Manuel Bodirski**

Generating Random Labeled Planar Graphs

We present an algorithm that efficiently generates a labeled planar graph on n nodes and m edges uniformly at random. We make use of recursive counting formulas for rooted 3-connected maps, decompositions of graphs into 3-connected components and a new algorithm of Schaeffer that generates rooted 3-connected maps.

3. 10:30-11:00, **Miloš Stojaković**

On Restricted Min-Wise Independence of Permutations

A family of permutations $\mathcal{F} \subseteq S_n$ with a probability distribution on it is called *k-restricted min-wise independent* if we have $\Pr[\min \pi(X) = \pi(x)] = \frac{1}{|X|}$ for every subset $X \subseteq [n]$ with $|X| \leq k$, every $x \in X$, and $\pi \in \mathcal{F}$ chosen at random.

A general method for finding lower bounds for the size of a probabilistic space is introduced. Using it we can prove that every k-restricted min-wise independentfamily has size at least $\binom{n-1}{\lfloor \frac{k-1}{2} \rfloor}$.

We also investigate the cases where the min-wise independence condition is required only for sets X of size *exactly* k (where we have only an $\Omega(\log\log n + k)$ lower bound), or for sets of size k and $k-1$ (where we already obtain a lower bound of $n-k+2$).

4. 11:00-11:30, **Mihyun Kang**

The Connectivity Threshold for the Min-Degree Random Graph Process

Let $\mathcal{G}_n = \{G_{\min}(n, M)\}_{M \geq 0}$ denote a min-degree random multigraph process in which $G_{\min}(n, M+1)$ is obtained from $G_{\min}(n, M)$ by connecting a randomly chosen vertex of a minimum degree with another vertex of the graph. We study the probability that the random mutligraph $G_{\min}(n, M)$ is connected. In particular, we show that when the minimum degree of $G_{\min}(n, M)$ reaches three it is connected with probability tending to 1 as $n \to \infty$.