37th International Workshop on Graph Theoretic Concepts in Computer Science

Collection of Abstracts

Tomáš Vyskočil (ed.)

Dear participants,

it is our great pleasure to welcome you to Teplá monastery for WG 2011. The 37th International Workshop on Graph Theoretic Concepts in Computer Science is returning to Czech Republic after 9 years, to a location where Luděk Kučera originally planned to hold WG 2002. We are happy that we can show you this interesting place and we hope that the atmosphere of the monastery will provide good vibrations for theoretical work and the adjacent properties will provide opportunity for relaxing strols.

We are also glad that during the conference we can celebrate the 65th birthday of Luděk Kučera, a Czech computer scientist who has has been on the WG steering committee for years and devoted a lot of his time and efforts to this conference series, even before the steering committee was formally formed.

Last but not least we would like to thank the institutions that sponsored or otherwise contributed to the conferfence - Department of Applied Mathematics KAM, Institute for Theoretical Computer Science ITI, Center for Discrete Mathematics and Theoretical Computer Science DIMATIA (all of Charles University), Znovín Znojmo, a.s., and, of course, the Premonstrate Monastery in Teplá.

Petr Kolman and Jan Kratochvíl

DIMATIA

ZNOVÍN ZNOJMO, a.s.
SE SÍDLEM V ŠATOVĚ

KAM

Tuesday June 21, 2011	
9:00-10:00	**Invited talk:** A. Matchetti-Spaccamela. *Structures and Hyperstructures in Metabolic Networks*
10:00	**Cofee Break**
10:30-10:55	Marek Cygan, Daniel Marx, Marcin Pilipczuk, Michal Pilipczuk and Ildiko Schlotter. *Parameterized Complexity of Eulerian Deletion Problems*
11:00-11:25	Manuel Sorge, René Van Bevern, Rolf Niedermeier and Mathias Weller. *From Few Components to an Eulerian Graph by Adding Arcs*
11:30-11:55	Daniel Lokshtanov, Matthias Mnich and Saket Saurabh. *Planar k-Path in Subexponential Time and Polynomial Space*
12:00-12:25	Toru Hasunuma and Hiroshi Nagamochi. *Improved Bounds for Minimum Fault-Tolerant Gossip Graphs*
12:30	**Lunch**
14:00-14:25	Andrew McGrae and Michele Zito. *Empires Make Cartography Hard: The Complexity of the Empire Colouring Problem*
14:30-14:55	Jean-Francois Couturier, Petr Golovach, Dieter Kratsch and Daniel Paulusma. *List Coloring in the Absence of a Linear Forest*
15:00-15:25	Ondřej Bílka, Jozef Jirásek, Pavel Klavík, Martin Tancer and Jan Volec. *On the Complexity of Planar Covering of Small Graphs*
15:30	**Cofee Break**
16:00-16:25	Felix Arends, Joel Ouaknine and Charles Wampler. *On Searching for Small Kochen-Specker Vector Systems*
16:30-16:55	Michael Pelsmajer, Marcus Schaefer, Daniel Štefankovič and Radoslav Fulek. *Hanani-Tutte and Monotone Drawings*
17:00-17:25	Christopher Auer and Andreas Gleißner. *Characterizations of Deque and Queue Graphs*
18:00	**Dinner**

Wednesday June 22, 2011	
9:00-9:25	Rémy Belmonte and Martin Vatshelle. *Graph Classes with Structured Neighborhoods and Algorithmic Applications*
9:30-9:55	Hisao Tamaki. *A Polynomial Time Algorithm for Bounded Directed Pathwidth*
10:00-10:25	Yota Otachi, Toshiki Saitoh, Katsuhisa Yamanaka, Shuji Kijima, Yoshio Okamoto, Hirotaka Ono, Yushi Uno and Koichi Yamazaki. *Approximability of the Path-Distance-Width for AT-free Graphs*
10:30	**Coffee Break**
11:00-11:25	Konstanty Junosza-Szaniawski, Zbigniew Lonc and Michal Tuczynski. *Counting Independent Sets in Claw-Free Graphs*
11:30-11:55	Christine Cheng, Eric McDermid and Ichiro Suzuki. *Planarization and Acyclic Colorings of Subcubic Claw-Free Graphs*
12:00-12:55	Iyad Kanj and Fenghui Zhang. *On the Independence Number of Graphs with Maximum Degree 3*
12:30	**Lunch**
14:00	**Monastery sightseeing tour**
15:30	**Coffee Break**
16:00-16:25	Liliana Alcon, Luerbio Faria, Celina Figueiredo and Marisa Gutierrez. *Split Clique Graph Complexity*
16:30-16:55	Serge Gaspers, Mathieu Liedloff, Maya Stein and Karol Suchan. *Complexity of Splits Reconstruction for Low-Degree Trees*
17:00-17:25	Marijke Bodlaender, Cor Hurkens and Gerhard J. Woeginger. *The Cinderella Game on Holes and Anti-Holes*
17:30-17:55	Hans L. Bodlaender and Dieter Kratsch. *Exact Algorithms for Kayles*
18:30	**Concert**
20:00	**Banquet**

Thursday June 23, 2011	
9:00-10:00	**Invited talk:** D. Marx. *Important Separators and Parameterized Algorithms*
10:00	**Coffee Break**
10:30-10:55	Andreas Emil Feldmann, Shantanu Das and Peter Widmayer. *Restricted Cuts for Bisections in Solid Grids*
11:00-11:25	Juraj Stacho, Elad Cohen and Steven Chaplick. *Recognizing Some Subclasses of Vertex Intersection Graphs of 0-Bend Paths in a Grid*
11:30-11:55	Holger Flier, Matus Mihalak, Anna Zych and Peter Widmayer. *Maximum Independent Set in 2-Direction Outersegment Graphs*
12:00-12:25	Alexander Ravsky and Oleg Verbitsky. *On Collinear Sets in Straight Line Drawings*
12:30	**Lunch**
14:00-14:25	Katarina Cechlarova and Eva Jelínková. *Approximability of Economic Equilibrium for Housing Markets With Duplicate Houses*
14:30-14:55	Danny Hermelin, Chien-Chung Huang, Stefan Kratsch and Magnus Wahlström. *Parameterized Two-Player Nash Equilibrium*
15:00-15:25	Ján Katrenič, František Galičík and Gabriel Semanišin. *On Computing an Optimal Semi-Matching*
15:30-15:55	Magnus M. Halldorsson, Sergey Kitaev and Artem Pyatking. *Alternation Graphs*
16:00	**Coffee Break**
17:00	Departure (from Teplá) of the bus to Prague, expected arrival to Prague around 19:00
18:00	**Dinner**

Conference Excursion - Friday June 24, 2011	
10:00	The Bečov castle - Sightseeing Tour
13:00	Lunch at the family brewery Chodovar
15:00	Brewery tour
17:00	Departure (from Chodovar) of the bus to Prague, expected arrival to Prague around 19:00

Invited talks

Tuesday, 9:00 - 10:00

Structures and Hyperstructures in Metabolic Networks

Alberto Marchetti-Spaccamela

A large interest for metabolism in the computational biology community has lead to an avalanche of papers. Here we focus our attention on the study of metabolic networks that allow to represent cells of plants and animals as "chemical factories" where the various products are manufactured. The goal is to understand cell metabolism as the complete set of chemical reactions that occur in living cells, each reaction corresponding to the transformation of a set of one or more substances into another set.

Various models have been proposed to represent metabolic networks using graph and hypergraphs and many problems have been studied. We present two such problems that are challenging also for their computational aspects. The first one is the problem of characterizing metabolism in the network. Several approaches have been proposed many of which require finding suitably defined paths (and hyperpaths) in the network. We will discuss how finding and enumerating such paths is related to known graph problems while posing new algorithmic challenges.

The second problem deals with the use of graph theoretic measures in order to mine the structures of a metabolic networks and to provide further insight into its general characteristics. We will review known results based on measures such as degree distribution, centrality, diameter, clustering coefficients and so on and we will also discuss new approaches based on treewidth and Kelly width.

Thursday, 9:00 - 10:00

Important Separators and Parameterized Algorithms

Dániel Marx

The notion of "important separators" and bounding the number of such separators turned out to be a very useful technique in the design of fixed-parameter tractable algorithms for multi(way) cut problems. For example, the recent breakthrough result of Chen et al. on the Directed Feedback Vertex Set problem can be also explained using this notion. In my talk, I will overview combinatorial and algorithmic results that can be obtained by studying such separators.

Contributed talks

Tuesday, 10:30 - 12:25

Parameterized Complexity of Eulerian Deletion Problems

Marek Cygan, Daniel Marx, Marcin Pilipczuk, Michal Pilipczuk and Ildiko Schlotter

We study a family of problems where the goal is to make a graph Eulerian by a minimum number of deletions. We completely classify the parameterized complexity of various versions: 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.

From Few Components to an Eulerian Graph by Adding Arcs

Manuel Sorge, René Van Bevern, Rolf Niedermeier and Mathias Weller

Eulerian Extension (EE) is the problem to make an arc-weighted directed multigraph Eulerian by adding arcs at minimum cost. EE is NP-hard and has been shown fixed-parameter tractable with respect to the number of arc additions. Complementing this result, on the way to answering a long-standing open question, we show that EE is fixed-parameter tractable with respect to the combined parameter "number of connected components in the underlying undirected multigraph" and "sum of $\mathrm{indeg}(v) - \mathrm{outdeg}(v)$ over all vertices v in the input multigraph where this value is positive." Moreover, we show that EE has no polynomial-size problem kernel with respect to this parameter combination and for the parameter "number of arc additions".

Planar k-Path in Subexponential Time and Polynomial Space

Daniel Lokshtanov, Matthias Mnich and Saket Saurabh.

In the k-Path problem we are given a n-vertex graph G together with an integer k and asked whether G contains a path of length k as a subgraph. We give the first subexponential time, polynomial space parameterized algorithm for k-Path on planar graphs, and more generally, on H-minor-free graphs. The running time of our algorithm is $2^{O(\sqrt{k}\log^2 k)} \cdot n^{O(1)}$.

Improved Bounds for Minimum Fault-Tolerant Gossip Graphs

Toru Hasunuma and Hiroshi Nagamochi

A k-fault-tolerant gossip graph is a (multiple) graph whose edges are linearly ordered such that for any ordered pair of vertices u and v, there are $k+1$ edge-disjoint ascending paths from u to v. Let $\tau(n,k)$ denote the minimum number of edges in a k-fault-tolerant gossip graph with n vertices. In this paper, we present upper and lower bounds on $\tau(n,k)$ which improve the previously known bounds. In particular, from our upper bounds, it follows that $\tau(n,k) \leq \frac{nk}{2} + O(n \log n)$. Previously, it has been shown that this upper bound holds only for the case that n is a power of two.

Tuesday, 14:00 – 15:25

Empires Make Cartography Hard: The Complexity of the Empire Colouring Problem

Andrew McGrae and Michele Zito

We study the empire colouring problem (as defined by Percy Heawood in 1890) for maps containing empires formed by exactly $r > 1$ countries each. We prove that the problem can be solved in polynomial time using s colours on maps whose underlying adjacency graph has no induced subgraph of average degree larger than s/r. However, if $s >= 3$, the problem is NP-hard for forests of paths of arbitrary lengths (if $s < r$) for trees (if $s < 2r$) and arbitrary planar graphs (if $s < 7$ for $r = 2$, and $s < 6r - 3$, for $r >= 3$). The result for trees shows a perfect dichotomy (the problem is NP-hard if $3 <= s <= 2r - 1$ and polynomial time solvable otherwise). The one for planar graphs proves the NP-hardness of colouring with less than 7 colours graphs of thickness two and less than 6r-3 colours graphs of thickness $r >= 3$.

List Coloring in the Absence of a Linear Forest

Jean-Francois Couturier, Petr Golovach, Dieter Kratsch and Daniel Paulusma

The k-Coloring problem is to decide whether a graph can be colored with at most k colors such that no two adjacent vertices receive the same color. The List k-Coloring problem requires in addition that every vertex u must receive a color from some given subset $L(u)$ of $\{1, .., k\}$. Let P_n denote the path on n vertices, and $G+H$ and rH the disjoint union of two graphs G and H and r copies of H, respectively. For any two fixed integers k and r, we show that List k-Coloring can be solved in polynomial time for graphs with no induced $rP_1 + P_5$, hereby extending the result of Hoang, Kaminski, Lozin, Sawada and Shu for graphs with no induced P_5. Our result is tight; we prove that for any graph H that is a supergraph of $P_1 + P_5$ with at least 5 edges, already List 5-Coloring is NP-complete for graphs with no induced H. We then initiate a parameterized complexity study. We show that List k-Coloring is fixed parameter tractable in $k + r$ on graphs with no induced$rP_1 + P_2$, and that k-Coloring restricted to such graphs allows a polynomial kernel when parameterized by k. We also show that List k-Coloring is fixed parameter tractable in k for graphs with no induced $P_1 + P_3$.

On the Complexity of Planar Covering of Small Graphs

Ondřej Bílka, Jozef Jirásek, Pavel Klavík, Martin Tancer and Jan Volec

The problem Cover(H) asks whether an input graph G covers a fixed graph H (i.e., whether there is a homomorphism $G \to H$ which locally preserves the structure of the graphs). Complexity of this problem has been intensively studied. In this paper, we consider the problem PlanarCover(H) which restricts the input graph G to be planar.

PlanarCover(H) is polynomially solvable if Cover(H) belongs to P, and it is even trivially solvable if H has no planar cover. Thus the interesting cases are when H admits a planar cover, but Cover(H) is NP-complete. This also relates the problem to the long-standing Negami Conjecture which aims to describe all graphs having a planar cover. Kratochvíl asked whether there are non-trivial graphs for which Cover(H) is NP-complete but PlanarCover(H) belongs to P.

We examine the first nontrivial cases of graphs H for which

Cover(H) is NP-complete and which admit a planar cover. We prove NP-completeness of PlanarCover(H) in these cases.

Tuesday, 16:00-17:25

On Searching for Small Kochen-Specker Vector Systems

Felix Arends, Joel Ouaknine and Charles Wampler

Kochen-Specker (KS) vector systems are sets of vectors in R^3 with the property that it is impossible to assign $0s$ and $1s$ to the vectors in such a way that no two orthogonal vectors are assigned 0 and no three mutually orthogonal vectors are assigned 1. The existence of such sets forms the basis of the Kochen-Specker and Free Will theorems. Currently, the smallest known KS vector system contains 31 vectors. In this paper, we establish a lower bound of 18 on the size of any KS vector system. This requires us to consider a mix of graph-theoretic and topological embedding problems, which we investigate both from theoretical and practical angles. We propose several algorithms to tackle these problems and report on extensive experiments. At the time of writing, a large gap remains between the best lower and upper bounds for the minimum size of KS vector systems.

Hanani-Tutte and Monotone Drawings

Michael Pelsmajer, Marcus Schaefer, Daniel Štefankovič and Radoslav Fulek

A drawing of a graph is *x-monotone* if every edge intersects every vertical line at most once and every vertical line contains at most one vertex. Pach and Tóth showed that if a graph has an x-monotone drawing in which every pair of edges crosses an even number of times, then the graph has an x-monotone embedding in which the x-coordinates of all vertices are unchanged. We give a new proof of this result and strengthen it by showing that the conclusion remains true even if adjacent edges are allowed to cross oddly. This answers a question posed by Pach and Tóth. Moreover, we show that an extension of this result for graphs with non-adjacent pairs of edges crossing oddly fails.

Characterizations of Deque and Queue Graphs

Christopher Auer and Andreas Gleißner

In graph layouts the vertices of a graph are processed according to a linear order and the edges correspond to items in a data structure inserted and removed at their end vertices. Graph layouts characterize interesting classes of planar graphs: A graph G is a stack graph iff G is outerplanar, and a graph is a 2-stack graph iff it is a subgraph of a planar graph with a Hamiltonian cycle (Bernhart et al., 1979). (Heath and Rosenberg, 1992) characterized all queue graphs as the arched leveled-planar graphs. In (Auer and Gleiß, 2010), we have introduced linear cylindric drawings (LCDs) to study graph layouts in the double-ended queue (deque) and have shown that G is a deque graph iff it permits a plane LCD.

In this paper, we show that a graph is a deque graph iff it is the subgraph of a planar graph with a Hamiltonian path. In consequence, weo obtain that the dual of an embedded queue graph contains an Eulerian path. We also turn to the respective decision problem of deque graphs and show that it is NP-hard by proving that the Hamiltonian path problem in maximal planar graphs is NP-hard. Heath and Rosenberg, 1992 state that queue graphs are “almost” proper leveled-planar. We show that bipartiteness captures this “almost”: A graph is proper leveled-planar iff it is a bipartite queue graph.

Wednesday, 9:00 - 10:25

Graph Classes with Structured Neighborhoods and Algorithmic Applications

Rémy Belmonte and Martin Vatshelle

Boolean-width is a recently introduced graph width parameter. If a boolean decomposition of width w is given, several NP-complete problems, such as MAXIMUM WEIGHT INDEPENDENT SET, k-COLORING and MINIMUM WEIGHT DOMINATING SET are solvable in $O^*(2^{O(w)})$ time (Bui-Xuan et al., 2009). In this paper we study graph classes for which we can compute a decomposition of logarithmic boolean-width in polynomial time. Since $2^{O(\log n)} = n^{O(1)}$, this gives polynomial time algorithms for the above problems on these graph classes. We show how to construct decompositions where neighborhoods of vertex subsets are nested. More precisely, they can be represented by a constant number of vertices. Moreover we show that these decompositions have boolean-width $O(\log n)$. Graph classes having such decompositions include trapezoid graphs, circular permutation graphs, convex graphs, Dilworth k graphs, k-polygon graphs, circular arc graphs and complements of k-degenerate graphs. Combined with results in (Bui-Xuan et al., 2009), this implies that a large class of vertex subset and vertex partitioning problems can be solved in polynomial time on these graph classes.

A Polynomial Time algorithm for Bounded Directecd Pathwidth

Hisao Tamaki

We give a polynomial time algorithm for bounded directed pathwidth. Given a positive integer k and a digraph G with n vertices and m edges, it runs in $O(mn^{k+1})$ time and constructs a directed path-decomposition of G of width at most k if one exists and otherwise reports the non-existence.

Approximability of the Path-Distance-Width for AT-free Graphs

Yota Otachi, Toshiki Saitoh, Katsuhisa Yamanaka, Shuji Kijima, Yoshio Okamoto, Hirotaka Ono, Yushi Uno and Koichi Yamazaki

The path-distance-width of a graph measures how close the graph is to a path. We consider the problem of determining the path-distance-width for graphs with *chain-like structures* such as k-cocomparability graphs, AT-free graphs, and interval graphs. We first show that the problem is NP-hard even for a very restricted subclass of AT-free graphs. Next we present simple approximation algorithms with constant approximation ratios for graphs with chain-like structures. For instance, our algorithm for AT-free graphs has approximation factor 3 and runs in linear time. We also show that the problem is solvable in polynomial time for the class of cochain graphs, which is a subclass of the class of proper interval graphs.

Wednesday, 11:00 - 12:55

Counting Independent Sets in Claw-Free Graphs

Konstanty Junosza-Szaniawski, Zbigniew Lonc and Michal Tuczynski

In this paper we give an algorithm for counting the number of all independent sets in a claw-free graph which works in time $O^*(1.08352^n)$ for graphs with no vertices of degree larger than 3 and $O^*(1.23544^n)$ for arbitrary claw-free graphs, where n is the number of vertices in the instance graph. The algorithm is a modification of the algorithm of (Dahllöf et al., 2005) and (Whlström, 2008). In time analysis we use the measure and conquer method (Fomin et al., 2004) with a new interesting measure.

Planarization and Acyclic Colorings of Subcubic Claw-Free Graphs.

Christine Cheng, Eric McDermid and Ichiro Suzuki

We study methods of planarizing and acyclicly coloring claw-free subcubic graphs. We give a polynomial-time algorithm that, given such a graph G, produces an independent set Q of at most n/6 vertices whose removal from G leaves an induced planar subgraph P (in fact, P has treewidth at most four). We further show the stronger result that in polynomial-time a set of at most n/6 edges can be identified whose removal leaves a planar subgraph (of treewidth at most four). From an approximability point of view, we show that our results imply 6/5- and 9/8-approximation algorithms, respectively, for the (NP-hard) problems of finding a maximum induced planar subgraph and a maximum planar subgraph of a subcubic claw-free graph, respectively.

Regarding acyclic colorings, we give a polynomial-time algorithm that finds an optimal acyclic vertex coloring of a subcubic claw-free graph. To our knowledge, this represents the largest subclass of subcubic graphs such that an optimal acyclic vertex coloring can be found in polynomial-time. We show that this bound is tight by proving that the problem is NP-hard for cubic line graphs (and therefore, claw-free graphs) of maximum degree d at least 4. An interesting corollary to the algorithm that we present is that there are exactly three subcubic claw-free graphs that require four colors to be acyclicly colored. For all other such graphs, three colors suffice.

On the Independence Number of Graphs with Maximum Degree 3

Iyad Kanj and Fenghui Zhang

Let G be an undirected graph with maximum degree at most 3 such that G does not contain any of the three graphs shown in Figure 1 as a subgraph. We prove that the independence number of G is at least n(G)/3 + nt(G)/42, where n(G) is the number of vertices in G and nt(G) is the number of nontriangle vertices in G. This bound is tight as implied by the well-known tight lower bound of 5n(G)/14 on the independence number of triangle-free graphs of maximum degree at most 3.

We show an algorithmic application of this combinatorial result to the area of parameterized complexity. We give a linear-time kernelization algorithm for the independent set problem on graphs with maximum degree at most 3 that computes a kernel of size at most $140k/47 < 3k$, where k is the given parameter. This improves the known $3k$ upper bound on the kernel size for the problem, and implies a lower bound of $140k/93$ on the kernel size for the vertex cover problem on graphs with maximum degree at most 3.

Wednesday, 16:00 - 17:55

Split Clique Graph Complexity

Liliana Alcon, Luerbio Faria, Celina Figueiredo and Marisa Gutierrez

A *complete set* of a graph G is a subset of vertices inducing a complete subgraph. A *clique* is a maximal complete set. Denote by $\mathcal{C}(G)$ the *clique family* of G. The *clique graph* of G, denoted by $K(G)$, is the intersection graph of $\mathcal{C}(G)$. Say that G is *a clique graph* if there exists a graph H such that $G = K(H)$. The clique graph recognition problem, a long-standing open question posed in 1971, asks whether a given graph is a clique graph and it was recently proved to be NP-complete even for a graph G with maximum degree 14 and maximum clique size 12. Hence, if P≠NP, the study of graph classes where the problem can be proved to be polynomial, or of more restricted graph classes where the problem remains NP-complete is justified. We present a proof that given a split graph $G = (V, E)$ with partition (K, S) for V, where K is a complete set and S is a stable set, deciding whether there is a graph H such that G is the clique graph of H is NP-complete. As a byproduct, we prove that a problem about the Helly property on a family of sets is NP-complete. Our result is optimum in the sense that each vertex of the independent set of our split instance has degree at most 3, whereas when each vertex of the independent set has degree at most 2 the problem is polynomial, since it is reduced to check whether the clique family of the graph satisfies the Helly property. Additionally, we show three split graph subclasses for which the problem is polynomially solvable: the subclass where each vertex of S has a private neighbor, the subclass where $|S| \leq 3$, and the subclass where $|K| \leq 4$.

Complexity of Splits Reconstruction for Low-Degree Trees

Serge Gaspers, Mathieu Liedloff, Maya Stein and Karol Suchan.

Given a vertex-weighted tree T, the split of an edge xy in T is $\min(s_x, s_y)$ where s_x (respectively, s_y) is the sum of all weights of vertices that are closer to x than to y (respectively, closer to y than to x) in T. Given a set of weighted vertices V and a multiset of splits S, we consider the problem of constructing a tree on V whose splits correspond to S. The problem is known to be NP-complete, even when all vertices have unit weight and the maximum vertex degree of T is required to be no more than 4. We show that - the problem is strongly NP-complete when T is required to be a path. For this variant we exhibit an algorithm that runs in polynomial time when the number of distinct vertex weights is constant. We also show that - the problem is NP-complete when all vertices have unit weight and the maximum degree of T is required to be no more than 3, and - it remains NP-complete when all vertices have unit weight and T is required to be a caterpillar with unbounded hair length and maximum degree at most 3. Finally, we shortly discuss the problem when the vertex weights are not given but can be freely chosen by an algorithm.

The Cinderella Game on Holes and Anti-Holes
Marijke Bodlaender, Cor Hurkens and Gerhard J. Woeginger

We investigate a two-player game on graphs, where one player (Cinderella) wants to keep the behavior of an underlying water-bucket system stable whereas the other player (the wicked Stepmother) wants to cause overflows. The bucket number of a graph G is the smallest possible bucket size with which Cinderella can win the game.

We determine the bucket numbers of all perfect graphs, and we also derive results on the bucket numbers of certain non-perfect graphs. In particular, we analyze the game on holes and (partially) on anti-holes for the cases where Cinderella sticks to a simple greedy strategy.

Exact Algorithms for Kayles
Hans L. Bodlaender and Dieter Kratsch

In the game of Kayles, two players select alternatingly a vertex from a given graph G, but may never choose a vertex that is adjacent or equal to an already chosen vertex. The last player that can select a vertex wins the game. In this paper, we give an exact algorithm to determine which player has a winning strategy in this game. To analyse the running time of the algorithm, we introduce the notion of K-set: a nonempty set of vertices $W \subseteq V$ is a K-set in a graph $G = (V, E)$, if $G[W]$ is connected and there exists an independent set X such that $W = V - N(X)$, where $N(X)$ is the set of all vertices adjacent to at least one vertex of X. The running time of the algorithm is bounded by a polynomial factor times the number of K-sets in G. We show that the number of K-sets in a graph with n vertices is bounded by $O(1.6052^n)$, and thus we have an algorithm for KAYLES with running time $O(1.6052^n)$. We also show that the number of K-sets in a tree is bounded by $n \cdot 3^{n/3}$ and thus KAYLES can be solved on trees in $O(1.4423^n)$ time. We show that apart from a polynomial factor, the maximum number of K-sets in a tree on n vertices is sharp.

The considered problem is related to building libraries of chemical compounds used for drug design and discovery. In these inverse problems, the goal is to generate chemical compounds having desired structural properties, as there is a strong correlation between structural properties, such as the Wiener index, which is closely connected to the considered problem, and biological activity.

Thursday, 10:30 - 12:25

Restricted Cuts for Bisections in Solid Grids

Andreas Emil Feldmann, Shantanu Das and Peter Widmayer

The *graph bisection problem* asks to partition the n vertices of a graph into two sets of equal size so that the number of edges across the cut is minimum. We study finite, connected subgraphs of the infinite two-dimensional grid that do not have holes. Since bisection is an intricate problem, our interest is in the tradeoff between runtime and solution quality that we get by limiting ourselves to a special type of cut, namely cuts with at most one bend each (corner cuts). We prove that optimum corner cuts get us arbitrarily close to equal sized parts, and that this limitation makes us lose only a constant factor in the quality of the solution. We obtain our result by a thorough study of cuts in polygons and the effect of limiting these to corner cuts.

Recognizing Some Subclasses of Vertex Intersection Graphs of 0-Bend Paths in a Grid

Juraj Stacho, Elad Cohen and Steven Chaplick

We investigate graphs that can be represented as vertex intersections of horizontal and vertical paths in a grid, know as B_0-VPG graphs. Recognizing these graphs is an NP-hard problem. In light of this, we focus on their subclasses. In the paper, we describe polynomial time algorithms for recognizing chordal B_0-VPG graphs, and for recognizing B_0-VPG graphs that have a representation on a grid with 2 rows.

Maximum Independent Set in 2-Direction Outersegment Graphs

Holger Flier, Matúš Mihalák, Peter Widmayer and Anna Zych

An outersegment graph is the intersection graph of line-segments lying inside a disk and having one end-point on the boundary of the disk. We present a polynomial-time algorithm for the problem of computing a maximum independent set in outersegment graphs where every segment is either horizontally or vertically aligned. We assume that a geometric representation of the segments is given as input.

On Collinear Sets in Straight Line Drawings

Alexander Ravsky and Oleg Verbitsky

We consider straight-line drawings of a planar graph G with possible edge crossings. The *untangling problem* is to eliminate all edge crossings by moving as few vertices as possible to new positions. Let $\mathit{fix}(G)$ denote the maximum number of vertices that can be left fixed in the worst case among all drawings of G. In the *allocation problem*, we are given a planar graph G on n vertices together with an n-point set X in the plane and have to draw G without edge crossings so that as many vertices as possible are located in X. Let $\mathit{fit}(G)$ denote the maximum number of points fitting this purpose in the worst case among all n-point sets X. As $\mathit{fix}(G) \leq \mathit{fit}(G)$, we are interested in upper bounds for the latter and lower bounds for the former parameter.

For any $\epsilon > 0$, we construct an infinite sequence of graphs with $\mathit{fit}(G) = O(n^{\sigma+\epsilon})$, where $\sigma < 0.99$ is a known graph-theoretic constant, namely the shortness exponent for the class of cubic polyhedral graphs. To the best of our knowledge, this is the first example of graphs with $\mathit{fit}(G) = o(n)$. On the other hand, we prove that $\mathit{fix}(G) \geq \sqrt{n/30}$ for any graph G of tree-width at most 2. This extends the lower bound obtained by (Goaoc et al.i, 2009) for outerplanar graphs.

Our upper bound for *fit*(G) is based on the fact that the constructed graphs can have only few collinear vertices in any crossing-free drawing. To prove the lower bound for *fix*(G), we show that graphs of tree-width 2 admit drawings that have large sets of collinear vertices with some additional special properties.

Thursday, 14:00 - 15:55

Approximability of Economic Equilibrium for Housing Markets With Duplicate Houses

Katarina Cechlarova and Eva Jelínková

In a modification of the classical model of housing market which includes duplicate houses, economic equilibrium might not exist. As a measure of approximation the value $SAT(\mathcal{M})$ was proposed: the maximum number of satisfied agents in the market $\mathcal{M}$, where an agent is said to be satisfied if, given a set of prices, he gets a most preferred house in his budget set. Clearly, market $\mathcal{M}$ admits an economic equilibrium if $SAT(\mathcal{M})$ is equal to the total number n of agents, but $SAT(\mathcal{M})$ is NP-hard to compute.

In this paper we give a 2-approximation algorithm for $SAT(\mathcal{M})$ in the case of trichotomic preferences. On the other hand, we prove that $SAT(\mathcal{M})$ is hard to approximate within a factor smaller than 21/19, even if each house type is used for at most two houses. If the preferences are not required to be trichotomic, the problem is hard to approximate within a factor smaller than 1.2. We also prove that, provided the Unique Games Conjecture is true, approximation is hard within a factor 1.25 for trichotomic preferences, and within a factor 1.5 in the case of general preferences.

Parameterized Two-Player Nash Equilibrium

Danny Hermelin, Chien-Chung Huang, Stefan Kratsch and Magnus Wahlström

We study the problem of computing Nash equilibria in a two-player normal form (bimatrix) game from the perspective of parameterized complexity. Recent results proved hardness for a number of variants, when parameterized by the support size. We complement those results, by identifying three cases in which the problem becomes fixed-parameter tractable. Our results are based on a graph-theoretic representation of a bimatrix game, and on applying graph-theoretic tools on this representation.

On Computing an Optimal Semi-Matching

Ján Katrenič, František Galčík and Gabriel Semanišin

The problem of finding an optimal semi-matching is a generalization of the problem of finding classical matching in bipartite graphs. A *semi-matching* in a bipartite graph $G = (U, V, E)$ with n vertices and m edges is a set of edges $M \subseteq E$, such that each vertex in U is incident to at most one edge in M. An *optimal semi-matching* is a semi-matching with $deg_M(u) = 1$ for all $u \in U$ and the minimal value of $\sum_{v \in V} \frac{deg_M(v).(deg_M(v)+1)}{2}$. We propose a schema that allows a reduction of the studied problem to a variant of the maximum bounded-degree semi-matching problem. The proposed schema yields to two algorithms for computing an optimal semi-matching. The first one runs in time $O(\sqrt{n} \cdot m \cdot \log n)$ that is the same as the time complexity of the currently best known algorithm. However, our algorithm uses a different approach that enables some improvements in practice (e.g. parallelization, faster algorithms for special graph classes). The second one is randomized and it computes an optimal semi-matching with high probability in $O(n^{\omega})$, where ω is the exponent of the best known matrix multiplication algorithm. Since $\omega \leq 2.38$, this algorithms breaks through $O(n^{2.5})$ barrier for dense graphs.

Alternation Graphs

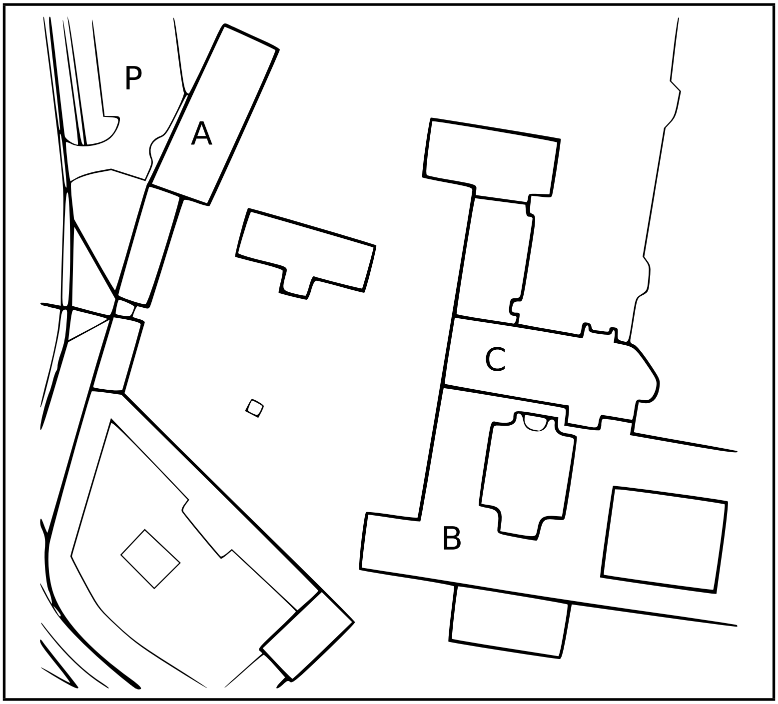
Magnus M. Halldorsson, Sergey Kitaev and Artem Pyatking

A graph $G = (V, E)$ is an *alternation graph* if there exists a word W over the alphabet V such that letters x and y alternate in W if and only if $(x, y) \in E$ for each $x \neq y$. These graphs correspond to precedence relations among recurrent tasks.

In this paper we give an effective characterization of alternation graphs in terms of orientations. Namely, we show that a graph is an alternation graph if and only if it admits a *semi-transitive orientation* defined in the paper. This allows us to prove a number of results about alternation graphs, in particular showing that the recognition problem is in NP, and that alternation graphs include all 3-colorable graphs.

We also explore bounds on the size of the word representation of the graph. A graph G is a k-*alternation* graph if it is represented by a word in which each letter occurs exactly k times; the alternation number of G is the minimum k for which G is a k-alternation graph. We show that the alternation number is always at most n, while there exist graphs for which it is $n/2$.

Plan of Monastery



A - **Hotel -** Accommodation and board
B - **Monastery -** Lecture room
C - **Church -** Organ concert
P - **Parking lot**