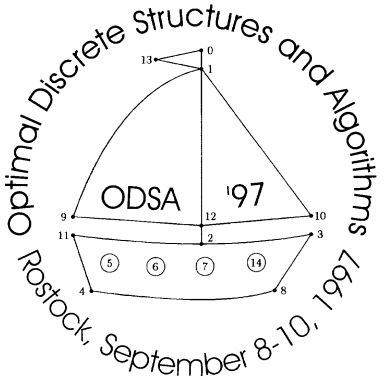
Optimal Discrete Structures and Algorithms

Universität Rostock, September 8 – 10, 1997

Abstracts



Optimal Discrete Structures and Algorithms

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Organizing Committee

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Abstracts

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Dear participants,

welcome to our first conference entitled

Optimal Discrete Structures and Algorithms.

It follows several Rostock- and Greifswald-conferences on Discrete Mathematics between 1970 and 1990. We wish that the conference stimulates a fruitful cooperation between scientists from Discrete Mathematics, Mathematical Optimization and Theoretical Computer Science.

For their support, we are indebted to our sponsors, the Deutsche Forschungsgemeinschaft, the Kultusministerium Mecklenburg-Vorpommern, the Institute of Combinatorics and its Applications, the Techniker Krankenkasse and the HUK-Coburg. We would like to thank all colleagues and students at the Department of Mathematics and Computer Science who contributed to the success of this conference.

We wish you a nice stay in Rostock, and of course many interesting talks and discussions with effective influence to your further research.

A. Brandstädt

K. Engel

H.-D. Gronau

R. Labahn

Plenary Talks

R. Ahlswede	Isoperimetric and isodiametric Theorems in Sequence Spaces
V. Alekseev	Logical semirings and their use for fast algorithms design
J. Bang-Jensen	Polynomial algorithms for path and cycle problems in generalizations of tournaments
F. Bennett	Perfect Mendelsohn Packing and Covering Designs
R. Canfield	Maximum sized antichains in the partition lattice
J. Dinitz	200 Years of MOLS : Making the New MOLS Table
P. Hammer	Logical analysis of data
D. Jungnickel	Geometric Sequence Design
R. Möhring	Graph-Theoretic Methods for the Generation of Quadrilateral Meshes in Computer-Aided Design
S. Olariu	On the P-Connectedness of Graphs

Section Talks

D. Acketa	Non-isomorphic $4-(48,5,\lambda)$ designs from $PSL(2,47)$
G. Alexe	On Hypergraphs with t-perfect Line Graphs
T. Andreae	A Game on Graphs where each Player tries to Block the Other Player's Men
A. Assaf	On The Covering of Pairs by Quintupel
L. Babel	Triangulating Graphs with Few P_4s
G. Bär	On the Complexity of Linear Programming in the BSS-model
D. Betten	The proper linear spaces on 17 points
C. Bey	The Erdős-Ko-Rado bound of the Function lattice
S. Bezrukov	
P. Braß	On Testing the Congruence of d-dimensional Point Sets
S. Cicerone	On the Extension of Bipartite to Parity Graphs
D. Cieslik	The Steiner Ratio of $\mathcal{L}_4^d$
K. Dohmen	Inclusion-Exclusion and Network Reliability
R. Dragan	Almost Diameter of a House-Hole-free Graph in Linear Time via LexBFS
F. Fomin	Helicopter search games on graphs
L. Foulds	On an Assignment Problem with Side Constraints
G. Fricke	Fractional Irredundance of Graphs
E. Girlich	The linear ordering polytope
H. Gropp	On some Generalizations of Symmetric Designs
M. Grüttmüller	On the Nonexistence of Pairwise Balanced Designs
Y. Guo	Outpaths of Vertices in Semicomplete Multipartite Digraphs
H. Harborth	Weakened Ramsey numbers
L. Harper	Reductions for a Problem of Sapozhenko
S. Hartmann	Asymptotic results on suborthogonal double covers of complete graphs
S. Hougardy	On Wings and Cycles
V. Kalashnikov	Extremal Values of the Entropy of a Finite Set Partitioned into Non-Empty Subsets
G. Khosrovshahi	On trading signed design algorithm
S. Klavžar	Recognizing median graphs
D. Kratsch	Dominating Pair Graphs – In the World surrounding Asteroidal Triple-Free Graphs

V. Le	Forest-Perfect Graphs
U. Leck	On some optimization problems for Macaulay posets
V. Leck	ODCs with additional properties
V. Leontiev	On the zeroes of boolean polynomials
Z. Lonc	Chain partitions and majorization
I. Mengersen	Ramsey-minimal Graphs for Matchings
D. Moazzami	Vulnerability in Graphs - a Comparative Survey
V. Mudrinski	A large collection of 2-designs from a wreath product on 21 points
C. Nocq	On the Linear Relaxation of the 2-Node Connected Subgraph Polytope
P. Östergård	Covering t-sets with $(t+2)$-sets
K. Reuter	The fractional dimension of subsets of Boolean lattices and of cartesian products
I. Rusu	An $O(m^2+mn)$ algorithm to recognize Meyniel graphs
M. Ruszinkó	On the Maximum Size of (p,q)–Cover–Free Families
A. Sali	Generalized Dependencies in Relational Databases
A. Sapozhenko	Almost all subsets of Cartesian product of graphs have a giant component
U. Schumacher	Suborthogonal Double Covers of the Complete Graph by isomorphic graphs
A. Shastri	Multi-Broadcasting in Communication Networks
R. Simanchev	The support inequalities and facets of combinatorial polytopes
G. di Stefano	Graph Classes between Parity and Distance-Hereditary Graphs
M. Sysło	Hamiltonicity of Amalgams
T. Szymczak	WWW–Information System on Graph Class Inclusions
P. Tittmann	Partitions and Network Reliability
S. de Vries	Polyhedral Methods for Discrete Tomography
A. Wagler	On a New Class of Extremal Perfect Graphs
A. Wassermann	Computer construction of simple t-designs

Other Participants

I. Bouchemakh, A. Brandstädt, E. Dahlhaus, K. Engel, R. El-Shanawany, H.-D. Gronau, S. Guttmann, M. Kovalev, R. Labahn, R. Lang, D. Lau, H. Lenz, C. Meise, H. Müller, R. Mullin, M. Naatz, V. Nalivaiko, E. Neidhardt, A. Rosa, J.-E. Rudolph, P. Scheffler, P. Schellenberg, H. Siemon, A. Straßburg, G. Tinhofer, I. Warnke, K. Weber

Monday, September 8

Aula (Main Building)

09.00 – 09.20 Opening

09.20 – 10.05 J. Dinitz
200 Years of MOLS : Making the New MOLS Table

10.35 – 11.20 R. Canfield
Maximum sized antichains in the partition lattice

Time	Section A Hörsaal 218	Section B Hörsaal 219	Section C Radisson SAS Hotel
14.00 14.25	D. Acketa Non-isomorphic $4-(48,5,\lambda)$ designs from $PSL(2,47)$	M. Sysło Hamiltonicity of Amalgams	S. Cicerone On the Extension of Bipartite to Parity Graphs
14.30 14.55	V. Mudrinski A large collection of 2-designs from a wreath product on 21 points	V. Kalashnikov Extremal Values of the Entropy of a Finite Set Partitioned into Non-Empty Subsets	V. Leontiev On the zeroes of boolean polynomials
15.00 15.25	M. Grüttmüller On the Nonexistence of Pairwise Balanced Designs	Z. Lonc Chain partitions and majorization	
15.30	coffee break		
16.00 16.25	H. Gropp On some Generalizations of Symmetric Designs	G. Bär On the Complexity of Linear Programming in the BSS-model	A. Sapozhenko Almost all subsets of Cartesian product of graphs have a giant component
16.30 16.55	V. Leck ODCs with additional properties	D. Cieslik The Steiner Ratio of $\mathcal{L}_4^d$	T. Szymczak WWW–Information System on Graph Class Inclusions
17.00 17.25	U. Schumacher Suborthogonal Double Covers of the Complete Graph by isomorphic graphs	F. Fomin Helicopter search games on graphs	A. Wagler On a New Class of Extremal Perfect Graphs
17.30 17.55	G. Khosrovshahi On trading signed design algorithm	T. Andreae A Game on Graphs where each Player tries to Block the Other Player's Men	

Tuesday, September 9

Aula (Main Building)

08.30 – 09.15 D. Jungnickel
Geometric Sequence Design

09.20 – 10.05 R. Ahlswede
Isoperimetric and isodiametric Theorems in Sequence Spaces

10.35 – 11.20 J. Bang-Jensen
Polynomial algorithms for path and cycle problems in generalizations of tournaments

11.25 – 12.10 R. Möhring
Graph-Theoretic Methods for the Generation of Quadrilateral Meshes in Computer-Aided Design

Time	Section A Hörsaal 218	Section B Hörsaal 219	Section C Radisson SAS Hotel
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14.30 14.55	A. Wassermann Computer construction of simple t-designs	Y. Guo Outpaths of Vertices in Semicomplete Multipartite Digraphs	D. Kratsch Dominating Pair Graphs – In the World surrounding Asteroidal Triple-Free Graphs
15.00 15.25	A. Assaf On The Covering of Pairs by Quintupel	P. Tittmann Partitions and Network Reliability	
15.30	coffee break		
16.00 16.25	D. Betten The proper linear spaces on 17 points	G. Alexe **Room 121** On Hypergraphs with t-perfect Line Graphs	G. Fricke Fractional Irredundance of Graphs
16.30 16.55	P. Östergård Covering t-sets with $(t+2)$-sets	S. de Vries Polyhedral Methods for Discrete Tomography	S. Hougardy On Wings and Cycles
17.00 17.25	S. Hartmann Asymptotic results on suborthogonal double covers of complete graphs	C. Nocq On the Linear Relaxation of the 2-Node Connected Subgraph Polytope	V. Le Forest-Perfect Graphs
17.30 17.55		R. Simanchev The support inequalities and facets of combinatorial polytopes	D. Moazzami Vulnerability in Graphs - a Comparative Survey

Wednesday, September 10

Hörsaal KIM

08.30 – 09.15 P. Hammer
Logical analysis of data

09.20 – 10.05 V. Alekseev
Logical semirings and their use for fast algorithms design

10.35 – 11.20 S. Olariu
On the P-Connectedness of Graphs

11.25 – 12.10 F. Bennett
Perfect Mendelsohn Packing and Covering Designs

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14.00 14.25	H. Harborth Weakened Ramsey numbers	A. Sali Generalized Dependencies in Relational Databases	G. di Stefano Graph Classes between Parity and Distance-Hereditary Graphs
14.30 14.55	I. Mengersen Ramsey-minimal Graphs for Matchings	L. Harper Reductions for a Problem of Sapozhenko	E. Girlich The linear ordering polytope
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16.30 16.55	P. Braß On Testing the Congruence of d-dimensional Point Sets	M. Ruszinkó On the Maximum Size of (p,q)–Cover–Free Families	S. Klavžar Recognizing median graphs
17.00 17.25		U. Leck On some optimization problems for Macaulay posets	I. Rusu An $O(m^2+mn)$ algorithm to recognize Meyniel graphs

Dragan Acketa, Novi Sad (Yugoslavia)
Vojislav Mudrinski and Staniša Dautović

Non-isomorphic $4-(48,5,\lambda)$ designs from $PSL(2,47)$

4-(48,5, λ) designs with $PSL(2,47)$ as automorphism group are enumerated. It turns out that there are 12, 295, 1195 and 2368 pairwise non-isomorphic designs in this class, with λ equal to $8, 12, 16, 20$, respectively. Auxiliary graphs serving as design invariants were used to derive this result.

The existing parameters λ within the considered class of designs are found by using a modification of the Kramer-Mesner method. Designs obtained by this method are appropriate column combinations of the orbit incidence matrix.

Using 3-homogenicity of $PSL(2,47)$, an auxiliary graph is adjoined to each design (column combination) so that the edges correspond to the blocks containing a fixed 3-subset of the ground-set. It turns out that each one of the adjoined graphs has exactly one isomorphic graph among the remaining adjoined graphs. Moreover, there exists an involutive mapping π that establishes isomorphism within all pairs of isomorphic adjoined graphs. The involution π belongs to $PGL(2,47)$ and maps a collection of PSL-orbits onto another one containing the same number of orbits. This leads to the conclusion that π establishes isomorphisms between the corresponding designs.

Rudolf Ahlswede, Bielefeld (Germany)

Isoperimetric and isodiametric Theorems in Sequence Spaces

Valeri Alekseev, Moscow (Russia)

Logical semirings and their use for fast algorithms design

A set with two operations — addition and multiplication — is said to be commutative semiring iff both operations are commutative and associative and multiplication is distributive over addition. By S_2 we denote semiring $\{0,1\}$ with disjunction (as addition) and conjunction S_2 (as multiplication).

Definition. Semiring A is said to be logical semiring iff there is a homomorphism of A on S_2.

For example, the set of nonnegative integers with usual operations is logical semiring (the map transforming 0 to 0 of S_2 and positive integers to 1 of S_2 is homomorphism).

The general idea how to use logical semirings for fast algorithms design is as follows. Many algorithmic problems for discrete objects are reduced to checking truth value of some statement in which quantifiers are over finite sets. In this case, we can replace all quantifiers by disjunction and conjunction and sometimes reduce the problem to calculating logical value of large expression over S_2. But instead of calculating T over S_2 we can first calculate some its homomorphic pre-image T' over some logical semiring A and then return to S_2 by homomorphism. Moreover, we can calculate the value of T' not in A but in any its extension.

Using this idea, author transforms some problems for recognition properties of discrete functions into problems of calculating polylinear forms over semirings and thus reduces asymptotical complexity of algorithms.

Gabriela Alexe, Galati (Romania)
S. Alexe and E. Olaru

On Hypergraphs with t-perfect Line Graphs

Let us call a *t-hypergraph* a hypergraph H whose line graph is t-perfect. Moreover, if the line graph of H is threshold, then H will be called a *threshold hypergraph.*

We give characterizations of these classes of hypergraphs. Some of them may be briefly formulated as:

A hypergraph H has the property that any partial hypergraph has a perfect matching if and only if it is a Helly t-hypergraph.

A hypergraph H has the property that any partial hypergraph has a perfect matching with at most one non-simple edge (i.e. an edge which contains another one) if and only if it is a Helly threshold-hypergraph.

Using these characterizations for the dual clique-hypergraph of a graph, we obtain some polynomial recognition algorithms for t-perfect graphs and for threshold graphs.

Other results, as are the following, refers to the properties of operations with t-hypergraphs:

The line graph of the strong product of two Helly t-hypergraphs is strongly perfect.

The line graph of the strong product of a Helly t-hypergraph and the dual hypergraph of a flower is both strongly and co-strongly perfect. (A hypergraph will be called a *flower* if the intersection of all its edges is the same with the intersection of any two of them and it is non-empty).

In particular, we obtain that: *The normal product of two t-perfect graphs is strongly-perfect,* which generalizes a previous result obtained by G. Ravindra, namely: *The normal product of two t-perfect graphs is perfect.*

Thomas Andreae, Hamburg (Germany)
Andrea Bode and Felix Hartenstein

A Game on Graphs where each Player tries to Block the Other Player's Men

We present results on a two person game which was proposed to one of the authors by Ingo Althöfer (personal communication). Given an undirected finite graph G without loops and multiple edges and a positive integer $k \leq \frac{|G|-1}{2}$, there are two players, called *white* and *black,* both having k men of their color. Beginning with white, the players take turns with placing a man of their color onto an unoccupied vertex of G, until all men are placed. There after, again beginning with white, the players take turns with moving a man of their color along an edge to an unoccupied neighbor. A player *wins* if his opponent cannot carry out his next move since none of his men has an unoccupied neighbor. If the game does not stop after a finite number of moves, then the outcome is a *draw.*

We always assume that both players play optimal. Among other questions, we consider the following ones: 1. Is it true that, for all G and k, white cannot win the game? 2. Does there exist a tree T and a positive integer k for which the outcome is a draw? Let $\tau(G)$ denote the *covering number* of G, i. e., $\tau(G)$ is the minimum number of vertices covering all edges of G. We prove that black wins if $\tau(G) \leq k$ and use this result to show that white never wins if G is bipartite, thus providing a partial answer to the first question. We answer the second question in the affirmative by constructing an infinite series of trees for which the outcome is a draw (for some k). In addition, we completely solve the cases when G is a path or a cycle and present results on extremal problems arising in the context of the game. We completely settle the case $k \leq 2$, too. In the proofs of our results, matchings and cycles in graphs play an important role.

Keywords: Combinatioral games, matchings and cycles in graphs, extremal graph theory, discrete pursuit–evasion games

Ahmed Assaf, Mt. Pleasant,MI (USA)

On The Covering of Pairs by Quintupel

Let V be a finite set of order v. A (v, k, λ) covering design of index λ and block size k is a collection of k-element subsets, called blocks, such that every 2-subset of V occurs in at least λ blocks. The covering problem is to determine the minimum number of blocks, $\alpha(v, k, \lambda)$, in a covering design. In this talk we determine the value of $\alpha(v, 5, \lambda)$ with a few possible exceptions.

Luitpold Babel, Munich (Germany)

Triangulating Graphs with Few P_4s

A *triangulation* of a graph G is a chordal graph on the same vertex-set that contains G as a partial subgraph. We address the problem of triangulating a graph such that either the number of added edges or the clique number of the generated graph is as small as possible. The two associated graph parameters are known as the *minimum fill-in* and the *treewidth*, respectively. The values of these and related parameters play an important role in sparse matrix factorization and have a number of other applications in areas such as VLSI-layout and algorithmic graph theory.

We first point out the use of the *homogeneous decomposition* of graphs for the purpose of triangulation. This new type of graph decomposition, introduced by Jamison and Olariu in [2], extends the well known *modular decomposition* in the sense that it goes further in decomposing graphs which are prime with respect to the modular decomposition. The result of the homogeneous decomposition is a tree which is unique up to labeled tree isomorphism.

Given an arbitrary graph G with the associated tree representation T, we show how to compute the parameters of G from the parameters of subgraphs that correspond to subtrees of T. As a direct application, we point out that the minimum fill-in and the treewidth can be determined in linear time for several interesting classes of (q,t)-*graphs*. These graphs have been introduced by Babel and Olariu in [1] as a generalization of known graph classes with a simple P_4-structure including *cographs*, P_4-*reducible graphs*, P_4-*extendible graphs* and P_4-*sparse graphs*. All these classes are characterized by containing – in some local sense – only a small number of induced P_4s.

References

[1] L. Babel, S. Olariu, On the isomorphism of graphs with few P_4s, in: M. Nagl, ed., *Graph-Theoretic Concepts in Computer Science, 21th International Workshop, WG'95,* Lecture Notes in Computer Science 1017, 24–36, Springer, Berlin, 1995 (also to appear in *Discrete Applied Mathematics*).

[2] B. Jamison, S. Olariu, p-components and the homogeneous decomposition of graphs, *SIAM J. Discrete Mathematics*, 8 (1995), 448–463.

Jørgen Bang-Jensen, Odense (Denmark)

Polynomial algorithms for path and cycle problems in generalizations of tournaments

A *tournament* is an orientation of a complete graph and a *semicomplete digraph* is a digraph with no pair of non-adjacent vertices. Thus a tournament is a semicomplete digraph with no cycle of length two. It is well known that the hamiltonian path and cycle problems can be solved efficiently in polynomial time for semicomplete digraphs. These algorithms are very simple and easy to implement. Within the last decade a number of interesting generalizations of tournaments and semicomplete digraphs have been studied. Some of these classes are very general and can have a quite complicated structure and yet we can still solve the hamiltonian path and cycle problems in polynomial time for these classes.

The purpose of this talk is to desribe some of the most important results on the algorithmic aspects of path and cycle problems for the various generalizations of tournaments. We will give details of some of the proofs to indicate the nice interplay between different classes of generalizations of tournaments. It should become evident from this lecture that even though the hamiltonian path and cycle problems are polynomially solvable for all the classes discussed, the solution can be highly non-trivial, even for these "tournament-like" digraphs. Finally we will also mention a number of challenging open problems.

Gunter Bär, Greifswald (Germany)

On the Complexity of Linear Programming in the BSS-model

Blum, Shub and Smale [1] have introduced a model of computation over the real numbers together with a theory of complexity (the so-called BSS-model). In this model especially all elements of $\mathbf{R}$ are considered to be of equal size.
Let the following sets be given:

$$F^k = \{f(x_1, ..., x_n) | \text{ f polynomial of n variables; } deg(f) \leq k\},$$

$$k \geq 1, \text{ integer },$$

$$F^2_{zero} = \{f \in F^2 | \text{ f has a real zero }\},$$

$$F^2_{zero,+} = \{f \in F^2 | \text{ f has a nonnegative real zero }\}.$$

Now we can formulate decision problems of the form (A, B) where $B \subset A$; for an input $a \in A$ is to decide whether $a \in B$ or not.

Already known results are

$$(F^4, F^4_{zero}) \in \mathbf{NP_R}\text{-complete}$$

$$(F^2, F^2_{zero}) \in \mathbf{P_R}$$

$$(LP, LP_{yes}) \leq_{\mathbf{R}} (F^2, F^2_{zero,+})$$

$$(3SAT, 3SAT_{yes}) \leq_{\mathbf{R}} (F^2, F^2_{zero,+}).$$

(LP, LP_{yes}) means the Linear Programming Feasibility Problem and
$(3SAT, 3SAT_{yes})$ is the special Satisfiability Problem with 3 literals per clause.

Let now the more special sets be given

$$F^{2+} = \{f \in F^2 | f(x_1, ..., x_n) \geq 0 \quad \forall x_j \in \mathbf{R}\},$$

$$F^{2+}_{zero} = F^{2+} \cap F^2_{zero} \text{ and } F^{2+}_{zero,+} = F^{2+} \cap F^2_{zero,+}.$$

In the talk we will show that the decision problem $(LP, LPyes)$ is polynomially equivalent to the decision problem $(F^{2+}, F^{2+}_{zero,+})$.

Reference:

Blum, L., Shub,M., Smale,S.: On a theory of computation and complexity over the real numbers. Bull. Amer. Math. Soc. 21 (1989), 1-46

Frank Bennett, Halifax (Canada)

Perfect Mendelsohn Packing and Covering Designs

A $(v, k, 1)$–perfect Mendelsohn packing (covering) design is a pair (X, A) where X is a v-set of points and A is a collection of cyclically ordered k-subsets of X, called blocks, such that every ordered pair of points of X appears t-apart in at most (at least) one block of A for all $t = 1, 2, \ldots, k-1$. If no other such packing (covering) has more (fewer) blocks, the packing (covering) is said to be maximum (minimum) and the number of blocks in a maximum packing (a minimum covering) is called the packing number (the covering number), denoted by $P(v, k, 1)$ ($C(v, k, 1)$). The packing problem is to determine the values of $P(v, k, 1)$ for all $v \geq k$. Similarly, the covering problem is to determine the values of $C(v, k, 1)$ for all $v \geq k$. The values of the functions $P(v, 3, 1)$ and $C(v, 3, 1)$ have been determined completely for all $v \geq 3$. The functions $P(v, 4, 1)$ and $C(v, 4, 1)$ have been determined for all $v \geq 4$, to within a handful of possible exceptions. For $k = 5$, the packing problem has been solved, with a few possible exceptions, but the covering problem remains to be investigated. We shall present a brief survey of the current results and mention some open problems. For the most part, the main results have been established on the strength of the existence of certain types of incomplete perfect Mendelsohn designs (IPMDs), which are of interest in their own right.

Dieter Betten, Giessen (Germany)

The proper linear spaces on 17 points

We recall the notion of a Tactical Decomposition (TD) for finite geometries and discuss some special cases of TDs. In particular we use TDOs (Tactical decompositions by ordering) to construct and to analyse finite geometries. With help of this TDO-Method it is possible to construct and classify all linear spaces on 17 points which have no 2-blocks.

Christian Bey, Rostock (Germany)

The Erdős-Ko-Rado bound of the Function lattice

We answer the following question: When does a k-uniform family generated by some rank t element in the Function lattice have maximum size among all k-uniform t-intersecting families?

Sergej Bezrukov, Paderborn (Germany)

tba

Wednesday, 15.00 Hörsaal 219

Peter Braß, Berlin (Germany)

On Testing the Congruence of d-dimensional Point Sets

Given two sets of n points in R^d each, we consider the problem of determining whether they are congruent, i.e. the problem of 'exact point pattern matching'. In dimensions two and three there are fast algorithms that solve this problem in $O(n \log(n))$ time; but for $d \geq 4$, there is only a $O(n^{d-2} \log(n))$ algorithm known. We present a $O(n^{\frac{d}{2}} \log(n))$ algorithm for $d \geq 4$ and show ways for further improvement.

Rod Canfield, Athens,GA (USA)

Maximum sized antichains in the partition lattice

In 1928 E. Sperner solved this problem: Given a finite ground set S of size n, what is the largest possible collection of subsets of S such that no two of the subsets are related by containment?

In the last twenty years, a generalization of this problem has been studied, namely: given a finite partially ordered set (poset), what is its largest antichain? (An antichain is a set of elements no two of which are related by the poset's order relation.)

Many interesting posets arise naturally in combinatorics, one of which is partitions of an n-set ordered by refinement. A partition of the n-set [n] = {1,2,...,n} is a collection of pairwise disjoint subsets, called blocks, whose union is [n]. One partition is a refinement of another if the first can be obtained by further partitioning the blocks of the second.

Determining the size of the largest antichain in this partition poset has spawned many general theorems in the subject now known as Sperner Theory. We will trace the study of large antichains in the partition lattice.

Serafino Cicerone, L'Aquila (Italy)
Gabriele Di Stefano

On the Extension of Bipartite to Parity Graphs

A fairly natural generalization of both distance-hereditary graphs and bipartite graphs is given by parity graphs. A graph is called parity if and only if, for any pair of vertices the lengths of all the induced paths joining them have the same parity.

They have been extensively studied, and several metric properties have been discovered. Burlet and Uhry gave the first structural characterization for these graphs. Based on such a result, they gave the first recognition algorithm for parity graphs working in $O(n^2)$ time, as well as algorithms to solve maximum weighted clique problem and maximum weighted independent set problem, both taking $O(n^3)$ time.

From then on some attempts have been done to improve the recognition time for parity graphs and to improve the time complexity of algorithms solving other basic problems. It is important to remark that all these works are based on the same characterization given by Burlet and Uhry and that they provide parallel algorithms.

But significant improvements of algorithmic solutions are often obtained only as a consequence of a better understanding on the structural properties of the graphs under consideration.

In this talk we newly describe a different structural property for parity graphs. This result is based on the split decomposition, which has been introduced by Cunningham to generalize the well-understood substitution decomposition theory.

We prove that split decomposition returns exactly cliques and bipartite graphs as building blocks of parity graphs, This result, together with the observation that the split decomposition process can be performed in linear time, give us a promising divide-and-conquer technique for solving computational problems in the class of parity graphs.

A remarkable consequence of this result is that the extension of bipartite graphs to parity graphs does not increase the complexity of basic problems we are considering, since the worst case occurs when the parity graph is an undecomposable bipartite graph. In particular, the following results have been achieved:

1. A linear time algorithm to solve the recognition problem of parity graph, improving the best known result that requires $O(n^2)$ time;

2. A linear time algorithm to solve the maximum weighted clique number problem of parity graph, improving the best known result that requires $O(n^2)$ time.

3. A general algorithm to solve the maximum weighted independent set problem in a generic class of graphs, assuming that the split decomposition produces subgraphs for which the same problem can be efficiently solved. We apply this general algorithm to:

3.1. parity graphs, giving rise to an algorithm whose time complexity is given by the time complexity of best algorithm that solves the same problem on bipartite graphs. This improves the best known result that requires $O(n^3)$ time.

3.2. distance-hereditary graphs, giving rise to a simple linear time algorithm.

Dietmar Cieslik, Greifswald (Germany)

The Steiner Ratio of $\mathcal{L}_4^d$

Let $\mathcal{L}_4^d$ be the d-dimensional affine space with 4-norm. Given a finite set N of points in this space. Find a connected graph $G = (V, E)$ such that $N \subseteq V$ and the total length of all edges of E is minimal. Such a network is called a Steiner Minimal Tree (SMT). If we connect pairs of given points only, we find a Minimum Spanning Tree (MST). Whereas an MST is easy to find a method to construct an SMT in $\mathcal{L}_4^d$ needs exponential time for $d = 2$ and is still unknown for $d > 2$. The Steiner Ratio $m(d)$ of $\mathcal{L}_4^d$ is the infimum of the quotients of the lengths of SMT and MST over all finite sets. We estimate this quantity.

Jeffrey H. Dinitz, Burlington,VT (USA)

200 Years of MOLS: Making the New MOLS Table

Sets of mutually orthogonal latin squares (MOLS) have been of interest to mathematicians since Euler first studied them over 200 years ago. They have proven to be of fundamental importance in combinatorial design theory as well as having uses in statistics, computer science, cryptography and coding theory. This talk will present a general overview of the construction techniques that have been developed over the years to find sets of MOLS. Also, a discussion of the computer program which created the new table of MOLS will be given.

Klaus Dohmen, Berlin (Germany)

Inclusion-Exclusion and Network Reliability

Algorithms based on the inclusion-exclusion principle play an important role in determining the reliability of a coherent binary system.

In this talk, we present an improvement of the inclusion-exclusion principle, in which the computational effort is significantly reduced. The results are applied in computing (and bounding) the two-terminal reliability of a directed network, a problem which is known to be $\#P$-complete.

Feodor Dragan, Rostock (Germany)

Almost Diameter of a House-Hole-free Graph in Linear Time via LexBFS

Let $G = (V, E)$ be a connected graph. The *distance* $d(v, u)$ between vertices v and u is the smallest number of edges in a path joining v and u. The *eccentricity* $e(v)$ of a vertex v is the maximum distance from v to any vertex in G. The *radius* $rad(G)$ is the minimum eccentricity of a vertex in G and the *diameter* $diam(G)$ is the maximum eccentricity. Distances in graphs and related graph theoretic parameters such as diameter and radius play an important role in the design and analysis of networks in a variety of networking environments like communication networks, electric power grids, and transportation networks. For example in communication networks usually the diameter is an approximation of the time needed to route a message.

As yet, no efficient algorithms for computing the diameter of an arbitrary graph, avoiding the computation of the whole distance matrix, has been designed. Linear time algorithms are known only for trees, 2-trees, maximal outerplanar graphs, interval graphs, strongly chordal graphs, dually chordal graphs, distance hereditary graphs and for graphs of benzenoid systems.

Even for chordal graphs efficient computation of the diameter is an open problem and it seems that the diameter problem on chordal graphs is not easier than 0,1 matrix multiplication. Nevertheless, as it was shown in [F.F. Dragan, F. Nicolai and A. Brandstädt, LexBFS–orderings and powers of graphs, *Proc. of the WG'96*, LNCS 1197, 166–180, 1997], using Lexicographic-Breadth-First-Search (LexBFS) of Rose, Tarjan and Lueker, one can find "almost" diameter of a chordal graph in linear time; the last numbered by LexBFS vertex has eccentricity equal to $diam(G)$ or $diam(G) - 1$. Moreover, using LexBFS one can find the exact diameter of an interval graph or a ptolemaic graph, and almost diameter of a distance hereditary graph or a weak bipolarizable graph.

Here we present similar results for more general graph classes: for HH-free graphs, for HHD-free graphs and for AT-free graphs.

A graph is *HH-free* if it does not contain a house (i. e. the complement of P_5) or a hole (a cycle of length at least 5) as an induced subgraph. A graph is *HHD-free* if it does not contain a house, a hole or a domino (the graph obtained from two 4-cycles by identifying an edge in one C_4 with an edge in the other C_4) as an induced subgraph. A graph is called *AT-free* if it does not have an *asteroidal triple*, i.e. a set of three vertices such that there is a path between any pair of them avoiding the closed neighborhood of the third.

Recall also that *LexBFS* orders vertices of a graph by assigning numbers from $n = |V|$ to 1 in the following way: assign the number k to a vertex v (as yet unnumbered) which has lexically largest vector $(s_i : i = n, n-1, \ldots, k+1)$, where $s_i = 1$ if v is adjacent to the vertex numbered i, and $s_i = 0$ otherwise.

Our main results are the following.

Let v be a vertex of G numbered by '1' in some LexBFS.

- If G is a HH-free graph then $e(v) \in \{diam(G), diam(G) - 1, diam(G) - 2\}$.
- If G is a HHD-free graph or an AT-free graph then $e(v) \in \{diam(G), diam(G) - 1\}$.
- If G is a HHD-free and AT-free graph then $e(v) = diam(G)$.

To prove these results we use special metric properties of HH-free graphs with respect to LexBFS.

Fedor Fomin, St. Petersburg (Russia)

Helicopter search games on graphs

We suggest an uniform game-theoretic approach to "width" graph parameters. A search problem on a graph in which one cop in a helicopter flying from vertex to vertex tries to catch the robber is considered. The existence of the winning program for the cop in this problem depends only on the robber's speed. We investigate the problem of finding the minimal robber's speed which prevents the cop to win. We examine different cases of the problem. In the first one the cop can visit each vertex of a graph only once. In the second case the cop can't afford "recontamination" of vertices and in the last case there is no restriction on cop's actions. We show that in the first case the problem of finding the minimal robber's speed is equivalent to the bandwidth minimization problem. In the second case we show that the problem is equivalent to the natural generalization of the bandwidth problem and is closely approximated by the pathwidth. And in the last case the minimal robber's speed is at least one half of the width (linkage). Also we discuss how and when "recontamination" helps the cop to win.

Les Foulds, Hamilton (New Zealand)
J. M. Wilson

On an Assignment Problem with Side Constraints

We describe a branch and bound algorithm for an assignment problem subject to a special set of side constraints. The problem has application in the design of tool carousels for certain flexible manufacturing systems. The resulting model represents a special case of the restricted facilities layout problem in which it is forbidden to locate any facility in certain zones. The bounds for the algorithm are generated by relaxing the side constraints and using the Hungarian method to solve the resulting assignment problem. Partitioning in a manner similar to subtour elimination for the travelling salesman problem leads to encouraging computational results.

Keywords: algorithms, assigment, heuristics, integer programming, side constraints.

Gerd Fricke, Dayton,OH (USA)
E. Cockayne and S. T. Hedetniemi

Fractional Irredundance of Graphs

A real-valued function $g : V \to [0,1]$ on the vertex set of a graph G is irredundant if $g(u) > 0$ implies there exists a vertex w in the closed neighborhood of $u, N[u]$, such that $g(N[w]) = 1$. Thus the definition for a function g to be irredundant is actually the minimality condition for a dominating function. Let $IR_f(G)$ and $ir_f(G)$ denote the supremum respectively infimum of the weights of all maximal irredundant functions on a graph G. We will show that $IR_f(G) = IR(G)$ for any graph G.

Eberhard Girlich, Magdeburg (Germany)

The linear ordering polytope

Harald Gropp, Heidelberg (Germany)

On some Generalizations of Symmetric Designs

Definition: A *symmetric (v,k,λ)-design* is a finite incidence structure of v elements and v blocks such that each block contains k elements, each element occurs on k blocks, and (*) 2 different elements occur in a common block exactly λ times.

This talk will discuss some of the following generalizations of this concept and investigate further properties of these discrete structures. Concerning the time restrictions I shall mainly focus on recent results on configurations.

Tactical Configurations: Without the above condition (*) we obtain a *tactical configuration TC(v,k)*. This structure was defined already by E.H.Moore in 1896, some first results were obtained by V. Martinetti in 1897. In modern terminology they correspond to regular bipartite graphs. For further information see [2].

Even Designs: For *even designs ED(v,k)* condition (*) is replaced by

(**) 2 different elements occur in a common block an even number of times.

Some first results are contained in [2].

Symmetric Configurations: For *symmetric configurations* v_k condition (*) is replaced by

(***) 2 different elements occur in a common block at most once.

Configurations were already defined in 1876 by Th. Reye and belong to the oldest discrete structures at all. In modern graph-theoretical terminology a configuration (v_r, b_k) is a linear r-regular k-uniform hypergraph with v vertices and b hyperedges. For a short survey and further references see [1].

Orbital Matrices: All the structures above can be described by square incidence matrices of entries 0 and 1 denoting the incidence of elements and blocks in the usual way. An *orbital matrix OM(v,k,x;λ)* is described by a corresponding matrix A of size v with non-negative integer entries and row and column sum k such that $AA^t = (k + x - \lambda)I_v + \lambda J_v$ where I_v and J_v denote the identity matrix and the all-one-matrix of size v and A^t denotes the transpose of A.

It turns out that the theorem of Schützenberger, Bruck, Ryser, and Chowla also holds for orbital matrices and yields many non-existence results. In contrast to symmetric design theory already many other non-existence results were obtained. For further information on orbital matrices see [3].

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[3] H. Gropp, On orbital matrices, in: Proceedings of "Conference on General Algebra and Discrete Mathematics", (eds.) K. Denecke, O. Lüders, Aachen (1997), 111-124

Martin Grüttmüller, Rostock (Germany)

On the Nonexistence of Pairwise Balanced Designs

Let K be a set of positive integers. Then a *pairwise balanced design* ($PBD[v, K]$) of order v with block sizes from K is a pair $(V, \mathcal{B})$, where V is a finite set (the *point set*) of cardinality v and $\mathcal{B}$ is a family of subsets (called *blocks*) of V which satisfy the following properties:

(i) if $B \in \mathcal{B}$, then $|B| \in K$;

(ii) every pair of distinct elements of V occurs in exactly one block of $\mathcal{B}$.

If we have, instead of (ii), that every pair of distinct elements of V occurs in at most one block of $\mathcal{B}$ than we call the pair $(V, \mathcal{B})$ *partial pairwise balanced design* ($PPBD[v, K]$).
A $PPBD[g, K']$ with point set G and block set $\mathcal{F}$ is called a *K-completable prestructure* if there exists a $PBD[v, K]$ where

(a) $G = V$, $\mathcal{F} \subseteq \mathcal{B}$ and $K' \subseteq K$

(b) $\forall B \in \mathcal{B} \setminus \mathcal{F}: \quad |B| \in K \setminus K'$

In this talk we describe properties of a completable prestructure by a system of equations and inequations. Nonexistence of a solution of this system implies nonexistence of a completable prestructure. We present results for $\{3\} \subset K \subseteq \{3, 4 \ldots, 21\}$ where $K \cap \{11, 12, \ldots, 21\} \neq \emptyset$ and for $K = \{3,k\}$ where $4 \leq k \leq 50$.
Furthermore we consider *PBD*s with mandatory blocks. A pairwise balanced design of order v with blocksizes from K has a *mandatory block* of size k^* if it contains a block of size k. Here we present results for $K = \{3,k^*\}$ where $4 \leq k \leq 44$.

Yubao Guo, Aachen (Germany)

Outpaths of Vertices in Semicomplete Multipartite Digraphs

An outpath of a vertex v in a digraph is an oriented path starting at v such that v dominates the endvertex of the path if and only if the endvertex also dominates v. A digraph obtained by replacing each edge of a complete n-partite graph with an arc or a pair of mutually opposite arcs is called a semicomplete n-partite digraph or a semicomplete multipartite digraph. We show that if D is a strongly connected semicomplete n-partite ($n \geq 3$) digraphs, then, for each $k \in \{3, 4, ..., n\}$ and each vertex v, D contains a $(k-1)$-outpath of v. This result is a generalization of Moon's theorem for tournaments (that states that every strong tournament is vertex pancyclic).

Peter Hammer, New Brunswick,NY (USA)

Logical analysis of data

In its original conception, the methodology of "Logical Analysis of Data (LAD) was designed for the discovery and utilization of "patterns" distinguishing the "true" and the "false" binary n-vectors ("observations") in a given dataset. The methodology of LAD was then extended (by using a "binarization" process) to datasets of "true" and "false" n-vectors of real numbers. Work currently in progress is aimed at further extending this methodology to the study of datasets of n-vectors of real numbers, with real-valued "outcomes" associated to the observations. The methods of LAD are based on combinatorial optimization and the theory of partially defined Boolean functions. This survey will:

1. describe the essential features of LAD and its extensions to the case of numerical data;

2. examine some mathematical problems related to LAD, including the study and the use of well-known and of new structured classes of Boolean functions;

3. discuss some algorithmic issues concerning LAD, including complexity questions involved in the binarization process;

4. present comparative results about the classification power of LAD, using datasets from the Depository of the University of California at Irvine;

5. outline uses of LAD in classification, data compression, construction of decision support systems, error detection, etc., based on case studies from medicine, economics, seismology, oil exploration, sociology, etc.

Heiko Harborth, Braunschweig (Germany)

Weakened Ramsey numbers

A classical Ramsey number $R = R(t;G)$ is the smallest number R such that every t–coloring of the edges of the complete graph K_R contains a monochromatic copy of a given graph G. Here we discuss first results of the weaker Ramsey numbers $R = R(s,t;G)$ where every t–coloring of the edges of K_R contains a copy of G with at most s colors.

Larry Harper, Riverside,CA (USA)

Reductions for a Problem of Sapozhenko

A. Sapozhenko has asked about the vertex-isoperimetric problem for the graph whose vertices are the n-tuples of 0's & 1's with exactly k 1's. Two vertices have an edge between them if they differ in exactly two places. We show how to reduce Sapozhenko's Problem to a special case of the vertex-isoperimetric problem for the Hamming graph, $(K_q)^d$, also recently solved by the author.

Sven Hartmann, Rostock (Germany)

Asymptotic results on suborthogonal double covers of complete graphs

A *suborthogonal double cover (SODC)* of K_n is a family $\mathcal{G} = \{G_1, \ldots, G_s\}$ of subgraphs of the complete graph K_n, called *pages*, such that every edge of K_n lies in exactly two pages and any two pages have at most one edge in common.

If, in addition, all pages are isomorphic to a given graph G, we call $\mathcal{G}$ an *SODC by* G. Necessary conditions for the existence of an SODC by G are

$$\begin{aligned} 2(n-1) &\equiv 0 \bmod d, \\ n(n-1) &\equiv 0 \bmod b, \end{aligned}$$

where b denotes the edge number of G and d the g.c.d. of the vertex degrees in G.

R. M. Wilson proved in 1975 that the complete graph K_n is decomposable into copies of a graph G whenever n is sufficiently large and certain necessary conditions hold.

Our objective is to give similar results for SODCs of K_n by a given graph G.

Stefan Hougardy, Berlin (Germany)

On Wings and Cycles

An edge in a graph G is called a *wing* if it is one of the two non-incident edges of an induced P_4 (a path on four vertices) in G. For a graph G its *wing-graph* $W(G)$ is defined as the graph whose vertices are the wings of G and two vertices in $W(G)$ are connected if the corresponding wings in G belong to the same P_4. We will characterize all graphs whose wing-graph is a cycle. This solves a conjecture posed by Hoàng in 1989.

Dieter Jungnickel, Augsburg (Germany)

Geometric Sequence Design

Periodic sequences with nice autocorrelation properties are important for a variety of applications (eg. in cryptography and signal processing), especially in the binary case. It turns out that these objects studied by engineers are equivalent to difference sets (and some generalizations) which were independently studied by design theorists for a long time. We report on the connections between these two areas and mention both recent results and open problems.

Vyacheslav Kalashnikov, Moscow (Russia)

Extremal Values of the Entropy of a Finite Set Partitioned into Non-Empty Subsets

Consider a finite set A of $N \geq 1$ elements and decompose it into m non-empty subsets $A_1, A_2, \ldots, A_m$ (hence $m \leq N$). Let n_i be the cardinality of the subset A_i, $i = 1, \ldots, m$. Define *an entropy* of the above partition to be

$$H(A_1, A_2, \ldots, A_m) = -\sum_{i=1}^{m} p_i \log_2 p_i, \tag{1}$$

where $p_i = n_i/N$, $i = 1, \ldots, N$.
In this paper, we aim at finding out extremal values of entropy function (1) in the *discrete* case, when the variables p_i assume only rational values n_i/N corresponding to different partitions of the set A into non-empty subsets A_i, $i = 1, \ldots, m$.

Definition 1. Two partitions $\alpha = (A_1, \ldots, A_m)$ and $\beta = (B_1, \ldots, B_m)$ of the set A into m non-empty subsets are *equivalent* ($\alpha \approx \beta$), if the vectors $(|A_1|, \ldots, |A_m|)$ and $(|B_1|, \ldots, |B_m|)$ are permutations of each other. Here $|C|$ is the number of elements of the subset C.

Lemma. *There exists a unique equivalence class with the following property: for each partition $\alpha = (A_1, \ldots, A_m)$ of that class, the cardinal numbers of the subsets A_i differ at most by the unity, i.e.*

$$-1 \leq |A_i| - |A_j| \leq 1, \quad i, j = 1, 2, \ldots, m. \tag{2}$$

Besides, if $p^* = 1/m$, for each partition of that class (and only for them) the relationship holds:

$$|p_i - p^*| < \frac{1}{N}, \quad i = 1, 2, \ldots, m; \tag{3}$$

here $p_i = |A_i|/N$.

Remark 1. The second statement of the Lemma shows that the partitions of the class $\mathcal{D}_q$ are closest to the element which maximizes the entropy H in the continuous case.

Define now an equivalence class $\mathcal{D}_1$ as a set of partitions equivalent to the partition $\beta = (B_1, \ldots, B_m)$ such that

$$|B_1| = 1, \ldots, |B_{m-1}| = 1, \ |B_m| = N - m + 1.$$

Theorem. *Entropy function* (1) *assumes its minimal value at the partitions of the class $\mathcal{D}_1$, whereas it achievs its maximum at the partitions of the class $\mathcal{D}_q$.*

Gholamreza B. Khosrovshahi, Theran (Iran)

On trading signed design algorithm

Sandi Klavžar, Maribor (Slovenia)

Recognizing median graphs

By now a rich theory has been developed for median graphs. They can be viewed as the natural common generalization of trees and hypercubes. Grid graphs and the covering graphs of distributive lattices are median graphs as well.

In this talk we will consider algorithms for recognizing median graphs. It is clear that median graphs can be recognized in polynomial time and a direct approach yields an $O(n^4)$ algorithm, where n is the number of vertices of a given graph. The fastest known algorithm for recognizing median graphs runs in $O(m\sqrt{n}) = O(n^{3/2}\log n)$ time, where m denotes the number of edges of a given graph. It will be shown that it is unlikely that this complexity can be improved. The reason is a reduction from recognizing triangle-free graphs to recognizing median graphs. In addition, it will be demonstrated that, loosely speaking, there are as many median graphs as there are triangle-free graphs. Some related classes of graphs will be mentioned as well.

Dieter Kratsch, Jena (Germany)

Dominating Pair Graphs – In the World surrounding Asteroidal Triple-Free Graphs

The long list of structural and algorithmic properties of AT-free graphs, mainly obtained by Corneil, Olariu and Stewart, has stimulated the search for larger classes of graphs with similar structural properties. In an earlier paper we proposed diametral path graphs and dominating pair graphs as promising graph classes 'in the world surrounding asteroidal triple-free graphs'.

A pair of vertices of a graph is a *dominating pair* if the vertex set of every path between these vertices is a dominating set of the graph. A graph is a *dominating pair graph* if each of its connected induced subgraphs has a dominating pair.

Dominating pair graphs form a superclass of the class of AT-free graphs. The purpose of our research is to study which of the structural properties of AT-free graphs can be extended to dominating pair graphs. The main result is an extension of the polar theorem for the dominating pairs in AT-free graphs to general graphs.

Theorem. Let $G = (V, E)$ be any graph with diameter at least 5. Then there are disjoint sets $X \subseteq V$ and $Y \subseteq V$ such that for all $x, y \in V$:

(x, y) is a dominating pair of G if and only if $x \in X$ and $y \in Y$.

We also study various other structural properties of dominating pair graphs, as e.g. the existence of so-called PATH-MCDS, i.e. connected dominating sets that induce a simple path, in connected dominating pair graphs. We characterize chordal dominating pair graphs and we give a necessary condition for dominating pair graphs in terms of asteroidal triples.

Van Bang Le, Rostock (Germany)
Andreas Brandstädt

Forest-Perfect Graphs

Two graphs G, H with the same vertex-set V are called P_4-*isomorphic* if there is a permutation π on V such that, for all subsets $S \subseteq V$, S induces a chordless path on four vertices (a P_4) in G if and only if $\pi(S)$ induces a P_4 in H. The Semi-Strong Perfect Graph Theorem (SSPGT) states that a graph is perfect if and only if it is P_4-isomorphic to perfect graph. This suggests to characterize those graphs which are P_4-isomorphic to a member in a (concrete) class $\mathcal{C}$ of perfect graphs. Such graphs are called $\mathcal{C}$-perfect; they are perfect by the SSPGT. Moereover, the class of $\mathcal{C}$-perfect graphs contains $\mathcal{C}$ as a subclass. Thus it is interesting to describe the $\mathcal{C}$-perfect graphs for the classical classes $\mathcal{C}$, for instance bipartite graphs, chordal graphs, comparability graphs, etc.

As a first result in this direction we shall describe the forest-perfect graphs and the tree-perfect graphs. They generalize the cographs and can be recognized efficiently. Moreover, the class of forest-perfect graphs properly contains the P_4-reducible graphs.

Uwe Leck, Rostock (Germany)

On some optimization problems for Macaulay posets

A ranked poset P is a Macaulay poset if there exists a linear ordering $\prec$ of its elements such that for any i and any subset F of the i-th level N_i, the shadow of the $|F|$ smallest (w.r.t. $\prec$) elements of N_i is a subset of the set of the smallest $|\Delta(F)|$ elements of N_{i-1}, where $\Delta(F)$ denotes the shadow of F.

We consider several optimization problems for Macaulay posets and provide solutions for a class of Macaulay posets which satisfy some axioms. In particular, this class contains cartesian products of chains, cartesian products of stars, as well as 0-1 subword orders.

Volker Leck, Rostock (Germany)

ODCs with additional properties

An Orthogonal Double Cover of the complete graph K_n (ODC) is a collection of n isomorphic graphs such that every two of them share exactly one edge and every edge of K_n occurs in exactly two of these graphs.

We discuss starters of ODCs (e.g. the boat in the logo) and their application to various constructions.

Vladimir Leontiev, Moscow (Russia)

On the zeroes of boolean polynomials

Zbigniew Lonc, Warsaw (Poland)

Chain partitions and majorization

We characterize sequences of positive integers $(m_1, ..., m_t)$, $m_1 \geq ... \geq m_t > 0$, for which the product $\mathbf{k} \times \mathbf{n}$ (of a k-element and an n-element chain), $k \leq n$, can be partitioned into chains $C_1, ..., C_t$ such that $|C_i| = m_i$, for $i = 1, ..., t$. The main result says that such a partition exists if and only if

$$\sum_{i=1}^{j} m_i \leq \sum_{i=1}^{j} (k + n + 1 - 2i),$$

for $j = 1, ..., k$ and

$$\sum_{i=1}^{t} m_i = kn.$$

Ingrid Mengersen, Braunschweig (Germany)
Jörg Oeckermann

Ramsey-minimal Graphs for Matchings

For a given pair of (simple, finite and undirected) graphs (G, H) a graph F is said to be a (G, H)-minimal graph if in any 2-coloring of the edges of F with green and red there is a green subgraph isomorphic to G or a red subgraph isomorphic to H and if there is no proper subgraph F' of F having this property.

Burr, Erdös, Faudree and Schelp proved that for a matching mK_2 and any graph H the set $\mathfrak{R}(mK_2, H)$ of all (mK_2, H)-minimal graphs (up to isomorphism) is finite. Nevertheless, the problem of determining all members of $\mathfrak{R}(mK_2, H)$ seems to be very difficult in general and is solved only for some very special graphs H and some small m.

We will present a characterization of the members of $\mathfrak{R}(mK_2, H)$ if H is a matching nK_2 or a star $K_{1,n}$ and describe large classes of graphs from $\mathfrak{R}(mK_2, H)$ if H is a path P_n or a cycle C_n. Moreover, $\mathfrak{R}(mK_2, H)$ is determined completely for some small graphs H.

Dara Moazzami, Tehran (Iran)

Vulnerability in Graphs - a Comparative Survey

The concept of tenacity of a graph G was introduced in Reference [5,6] as a useful measure of the "vulnerabilty" of G. In assessing the "vulnerability" of a graph one determines the extent to which the graph retains certain properties after the removal of vertices and / or edges. In this paper we will compare different measures of vulnerability with tenacity for several classes of graphs.

Rolf H. Möhring, Berlin (Germany)

Graph-Theoretic Methods for the Generation of Quadrilateral Meshes in Computer-Aided Design

A standard task in computer-aided design concerns the generation of quadrangle nets for modeling surfaces of work pieces (e. g. the wing of a car). This is usually done in a two-step approach in which a manually constructed coarse mesh is refined into into a suitably fine mesh that fulfills certain local conditions on density, angles etc. in order to enable a numerical analysis based on finite element methods.

We will present a graph-theoretic approach to automate the refinement process. It is based on the theory of bidirected flows, which form a generalization of flows in directed graphs and weighted matching problems in undirected graphs at the same time. The lecture will in particular report on how to model the refinement problem via bidirected flows, on the computational complexity of the refinement problem and on the algorithms and computational experience obtained with this approach.

The lecture is based on joint work with Matthias Müller-Hannemann, Berlin and Karsten Weihe, Konstanz.

Vojislav Mudrinski, Novi Sad (Yugoslavia)
Dragan Acketa and Snežana Matić–Kekić

A large collection of 2-designs from a wreath product on 21 points

The total of 4079 2-designs on 21 points have been found. All these designs have the same group as an automorphism group. This group can be represented as the wreath product of G and H, where G denotes the subgroup of order 3 of $PSL(2,2)$ and H denotes the transitive subgroup of order 21 of $PSL(3,2)$.

In particular, 1, 20, 101, 93, 173, 824 and 2867 values of λ for 2-(21,k,λ) designs have been detected, where k takes values from 4 through 10. Up to our knowledge, 2217 of these λ-values are new (14, 76, 65, 122, 587 and 1353, for k equal to 5, 6, ..., 10, respectively). By Alltop's extension, 1353 new 2-(21,10,λ) designs can be extended to the same number of new 3-(22,11,λ) designs.

Charles Nocq, Brest (France)
A.R. Mahjoub

On the Linear Relaxation of the 2-Node Connected Subgraph Polytope

A graph $G = (V, E)$ is said 2-node connected if between every pair of nodes of G, there are at least two node-disjoint paths. If there is a weight function associated with the edges of G, then *the 2-node connected subgraph problem* (TNCP) consists of finding a minimum weight 2-node connected spanning subgraph of G.

The problem TNCP has applications to the design of reliable communication and transportation networks.

If $W \subseteq V$, then the set of edges having one node in W and the other in $V \setminus W$ is called a *cut* of G and denoted by $\delta_G(W)$.

If $u \in V$, let $G \setminus u$ be the graph obtained from G by deleting u and the edges adjacent to u.

If $W \in \Re^E$ is a weight vector associated with the edges of E, then the problem TNCP on G can be formulated as follows

$$\begin{cases} \quad Min \quad wx & & \\ \text{st} & & \\ \quad 0 \leq x(e) \leq 1 & \forall e \in E & (1) \\ \quad x(\delta_G(W)) \geq 2 & \forall W \subset V, \ \ W \neq \emptyset & (2) \\ \quad x(\delta_{G \setminus u}(Z)) \geq 1 & \forall u \in V, \ Z \neq \emptyset, \ Z \subset V \setminus \{u\} & (3) \\ \quad x(e) \in \{0, 1\} & & (4) \end{cases}$$

Using flow techniques, the separation problem associated with constraints $(1) - (3)$ can be solved in polynomial time.

We study the polytope $P(G)$ given by inequalities $(1) - (3)$. We define an ordering on the extreme points of $P(G)$, and we characterize those fractional extreme points which are minimal with respect to that ordering. As a consequence, we obtain a polynomial method to separate a minimal fractional extreme point of $P(G)$. And we identify a new class of facets of the 2-node connected subgraph polytope. This is used in the framework of a cutting plane algorithm to solve instances of both TNCP and the traveling salesman problem.

Stephan Olariu, Norfolk,VA (USA)

On the P-Connectedness of Graphs

A graph is said to be p-connected is for every partition of its vertices into two non-empty, disjoint, sets some chordless path with three edges contains vertices from both sets in the partition. As it turns out, p-connectedness generalizes the usual connectedness of graphs and leads, in a naturally way, to a unique tree representation for arbitrary graphs.

This talk reviews old and new results, both structural and algorithmic, about p-connectedness along with applications to various graph decompositions.

Patric Östergård, Helsinki (Finland)
Kari J. Nurmela

Covering t-sets with $(t+2)$-sets

We use the following standard notations. A $t-(v,k,\lambda)$ *covering design* is a pair $(X,\mathcal{B})$, where X is a v-set of points and $\mathcal{B}$ is a family of k-subsets of X, called blocks, such that every t-subset of X is contained in at least λ blocks. The minimum number of blocks in a $t-(v,k,\lambda)$ covering design is denoted by $C_\lambda(v,k,t)$.

Exact values of $C_\lambda(v,k,t)$ are known only for certain sets of parameters, for example, when the values of these parameters are relatively small. In other cases, lower and upper bounds on the value of this function are known. Upper bounds are obtained by explicitly constructing corresponding covering designs either by algebraic and combinatorial constructions or, like in this paper, by a computer search.

We formulate the problem of constructing covering designs as a combinatorial optimization problem, where a global optimum corresponds to a desired covering design. In trying to solve these optimization instances, we use a stochastic local search heuristics, *tabu search*. Furthermore, we predetermine automorphisms of desired covering designs to facilitate the search; then we try to find sets of orbits of blocks leading to record-breaking bounds.

The authors have recently used this method [2] to update upper bounds on $C_1(v,t+1,t)$. We here continue this research and consider the function $C_1(v,t+2,t)$, that is, we want to cover all t-sets of a v-set using $(t+2)$-sets. A large number of new bounds is found, which lead to other improvements by different combinatorial methods. We give a table of $C_1(v,t+2,t)$ for $v \leq 28$ and $t \leq 8$, updating parts of the tables in [1] and list the new covering designs.

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Klaus Reuter, Hamburg (Germany)
Utz Leimich

The fractional dimension of subsets of Boolean lattices and of cartesian products

The fractional dimension of an ordered set has been introduced by G.R. Brightwell and E.R. Scheinerman in a paper from 1992. This relaxation parameter is an interesting variant of the well studied order dimension and can be considered as a special case of the fractional covering number of hypergraphs. We present three new results on this parameter: The fractional dimension of the poset consisting of the j and $k-$level ($j < k$) of a Boolean lattice is $k - j + 2$. Second, a formula for the product of standard orders, and third, the fact that fractional dimension is closed under MacNeille completion.

Irena Rusu, Orleans (France)
F. Roussel

An $O(m^2 + mn)$ algorithm to recognize Meyniel graphs

A graph G is said to be a *Meyniel graph* if every odd cycle (on at least five vertices) of G contains at least two chords. The introduction in [2] of these graphs had a double interest: firstly, they generalize i-triangulated and parity graphs, two of the most important classes of perfect graphs known at the time; secondly, the proof of their perfection contains the idea of improving a coloring of a graph by switching the colours in a bi-coloured subgraph.

In [1], Burlet and Fonlupt propose a polynomial algorithm to recognize Meyniel graphs, whose complexity is estimated to $O(n^7)$. It relies on the following property: the class of Meyniel graphs may be obtained from some *basic Meyniel graphs* using a binary operation called *amalgam*. Unfortunately, it is quite expensive to verify if a given graph is the amalgam of two graphs, and this supports the idea that a new point of view is needed to find a more efficient algorithm.

Our approach of Meyniel graphs will be directed through the search of a general structure, although it will not completely succeed. Intuitively, a Meyniel graph either will have no long cycle (and then no structure will be find), or will have a skeleton around which the rest of the graph will be regularly organized. Recognizing the first type of graphs will be the easy part of the algorithm. For the second type, a repetitive removal of special edges will be done in order to destroy the long cycles (without changing the nature of the graph), thus bringing the problem to the easier case before.

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Miklós Ruszinkó, Budapest (Hungary)

On the Maximum Size of (p,q)–Cover–Free Families

A (p,q)-*cover* is a family containing p sets such that each element of their union is contained in exactly $q(<p)$ members of the family. A family $\mathcal{F}$ of subsets of an n-set is (p,q)-*cover-free* if it does not contain a subfamily forming a (p,q)-*cover*. The problem is to find the maximum size $f(n,p,q)$ of such families. The special case $p=5$ and $q=3$ arose from number theory. Since all subsets of an n-set containing a fixed element form a (p,q)-*cover-free* family, the ratio $f(n,p,q)/2^n$ is between $1/2$ and 1. In the recent paper it is proved, that for $p>2q$ this ratio is 1, and for $p\leq 2q$ it is $\leq 1-c_{p,q}$. On the other hand a construction is given which shows that in this range the gap between the trivial 2^{n-1} lower bound and $f(n,p,q)$ can be large, more precisely this construction shows that $f(n,p,p-1)\geq 2^{n-1}+(1-o(1))n^{p-3}$. Also the exact value of $f(n,q,2q)$ is determined. Several related questions are posed. The results are joint with Z. Füredi and A. Gyárfás.

Attila Sali, Budapest (Hungary)

Generalized Dependencies in Relational Databases

Alexander Sapozhenko, Moscow (Russia)

Almost all subsets of Cartesian product of graphs have a giant component

Ulrike Schumacher, Rostock (Germany)

Suborthogonal Double Covers of the Complete Graph by isomorphic graphs

The well known concept of orthogonal double covers was generalised to suborthogonality. We look for a collection of subgraphs of the complete graph K_n all being identical copies of a given graph G such that every edge of the K_n is contained in exactly two copies and two copies have at most one edge in common, The problem is solved for stars. Beside that we consider complete bipartite graphs, paths and cycles.

Aditya Shastri, Banasthali Vidyapith (India)

Multi-Broadcasting in Communication Networks

Broadcasting is the process of information dissemination in communication networks (modelled as graphs) whereby a message originated at one vertex is transmitted to all members through a series of calls under the constraint that each call requires one unit of time and at every step any member can call at most one of its neighbours. In this paper, we study a variation of this problem in which one vertex is allowed to broadcast to a bounded number c of its neighbours. A *c–broadcast graph* on n vertices is a network in which message can be broadcast in $\lceil \log_{(c+1)} n \rceil$ time units regardless of the originator. The sparsest possible c–broadcast graphs for $c = 2, 3$ are constructed for some small values of n. We also consider the time-relaxed case for 2-Broadcast Graphs and 3-Broadcast Graphs where slightly more time than the optimal of $\lceil \log_3 n \rceil$ and $\lceil \log_4 n \rceil$, respectively, is allowed.

Keywords: broadcasting, graphs, networks, communication

Ruslan Simanchev, Omsk (Russia)

The support inequalities and facets of combinatorial polytopes

We will be interested in the convex hull of the combinatorial sets. Formulation of this question is follow. Let E be a finite set and $\mathcal{H}$ be the family of its subsets. We consider the family $\mathcal{H}$ wich is *combinatorially full*, i.e. 1) for any $e \in E$ there exist $H_1, H_2 \in \mathcal{H}$ such that $e \in H_1 \setminus H_2$ and 2) for any $e_1, e_2 \in E$ there exists $H \in \mathcal{H}$ such that $e_1 \in H$ and $e_2 \notin H$. Let R^E is an Euclidean space of the vector–columns with components indexed dy the elements of E. For $W \subseteq E$ define the $x^W \in R^E$ by setting $x^W_e = 1$ if $e \in W$ and $x^W_e = 0$ if $e \notin W$. Now $P(\mathcal{H}) = \mathrm{conv}\{x^H \in R^E \mid h \in \mathcal{H}\}$. The proper face of $P(\mathcal{H})$ is called a *facet* if its dimension is equal to $(\dim P(\mathcal{H}) - 1)$, and corresponding support inequality $c^T x \leq c_0$ is called *facet inducing*.

The base result is follow. Let the inequality $c^T x \leq c_0$ is supporting to $P(\mathcal{H})$. We call a *$c\mathcal{H}$–set* a nonemptyset $S \subset E$ such that $S = (H_1 \setminus H_2) \cup (H_2 \setminus H_1)$ and $c^T x^{H_1} = c^T x^{H_2} = c_0$ for some $H_1, H_2 \in \mathcal{H}$. The $e_0 \in E$ is a *$c\mathcal{H}$–consequence* of the set $\tilde{E} \subset E$ if there exists an ordered set $e_1, e_2, \ldots, e_t = e_0$ such that for any i the element e_i belong to some $c\mathcal{H}$–set in $\tilde{E} \cup \{e_1, e_2, \ldots, e_i\}$.

Theorem. Let $c^T x \leq c_0$ be a supporting inequality to $P(\mathcal{H})$, $\mathrm{aff} P(\mathcal{H}) = \{x \in R^E \mid A^T x = \alpha\}$ and the matrix A has full rank wich is equal to n. Assume that there exists a set $\tilde{E} \subset E$ such that 1) $|\tilde{E}| = n + 1$; 2) every $e \in E \setminus \tilde{E}$ is a $c\mathcal{H}$–consequence of $\tilde{E}$; 3) the submatrix of matrix $(c|A)$ wich maked up by rows in $\tilde{E}$ has full rank. Then the inequality $c^T x \leq c_0$ is facet inducing for $P(\mathcal{H})$.

In addition are obtained same necessary conditions of combinatorial type for the facet inducing inequalities. This techniques is rather cumbersome. However concrete definitions of the family $\mathcal{H}$, the affine hull and support inequalities permit to obtain constructive results (see [1]).

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Gabriele di Stefano, L'Aquila (Italy)
Serafino Cicerone

Graph Classes between Parity and Distance-Hereditary Graphs

Parity graphs and distance-hereditary graphs have been thoroughly studied because of their interesting metric properties. A graph is parity if and only if the lengths of any two induced paths joining the same pair of vertices have the same parity; on the other hand, a graph is distance-hereditary if and only if the lengths of such pair of paths are equal. Other important characterizations have been formed out for such graphs based on forbidden induced subgraphs and on generative operations for recursive definitions. With respect to the latter characterization, both parity and distance-hereditary graphs are generable, starting from a single vertex, using the following operations: extensions obtained by adding true and false twins or by adding certain bipartite graphs. The latter operation appends an arbitrary bipartite graph for parity graphs, and the smallest non-trivial bipartite graph for distance-hereditary graphs.

Metric and generative definitions stress the gap between the two classes, which is further confirmed by observing results about algorithmic studies on classic optimization problems. STEINER TREE, CONNECTED DOMINATION, and HAMILTONIAN PATH problems are NP-complete in parity graphs, because they are in bipartite graphs, and are solvable in polynomial time for distance-hereditary graphs. Another fundamental problem in the algorithmic graph theory is the ISOMORPHISM PROBLEM. It is still open for general graphs and the problem of bipartite graph isomorphism has been proved to be *isomorphism complete*, that is, polynomial-time equivalent to graph isomorphism in general. However, in the class of distance-hereditary graphs ISOMORPHISM PROBLEM is solvable in polynomial time.

The aim of this talk is to show some results about newly defined graph classes between distance-hereditary and parity graphs, introduced to provide a reference framework for studying the computational complexity of fundamental graph problems. We define a family of graph classes where each class is generated by an operation that extends graphs by appending specific bipartite graphs. Hence, for any particular class of bipartite graphs, we have a corresponding class in the family. We prove that such a family of classes is an infinite lattice with respect to inclusion relation, whose bottom and top elements are the class of the distance-hereditary graphs and the class of the parity graphs, respectively.

Based on split decomposition, we give a characterization for each class in the lattice, defining the decomposition structure of graphs in an arbitrary class. A consequence of this result is the development of a polynomial time recognition algorithm for each class, assuming a polynomial recognition algorithm for the corresponding bipartite class. Since the proposed characterization provides a particular tree structure for graphs in the family classes, we also show that the ISOMORPHISM PROBLEM is solvable in polynomial time for some classes in the defined family.

Maciej Sysło, Wrocław (Poland)
A. M. Farley, A. Prokurowski and M. Skowrońska

Hamiltonicity of Amalgams

An amalgam is obtained from two Halin graphs having skirting cycles of the same length. We are interested in Hamiltonicity of amalgams constructed from two identical Halin graphs without any shift along the skirting cycle. We establish Hamiltonicity of amalgams constructed from cubic Halin graphs. We give a sufficient condition for Hamiltonicity of non–cubic amalgams and characterize Hamiltonicity of amalgams constructed by shifting the component Halin graphs by one and of general amalgams of higher degree.

Thomas Szymczak, Rostock (Germany)
A. Brandstädt, V. B. Le, and J. Westermann

WWW–Information System on Graph Class Inclusions

Special graph classes are interesting for several topics of discrete mathematics and theoretical computer science such as the time complexity of some algorithmic problems restricted to special graphs. Up to know, more than 200 graph classes and their inclusions have been studied. The survey of A. Brandstädt, Special graph classes — a survey, Technical Report, Gerhard–Mercator–Universität – GH – Duisburg, SM-DU-199, 1993, is one of the attempts to collect the information from this rapidly developing field.

Meanwhile a program system has been developed in the diploma thesis of Jens Westermann connecting an updated knowledge base of graph class inclusions with the possibility to ask queries about inclusions of classes and using graph drawing programs to draw inclusion diagrams selected by users.

The system is still in test phase. You can access it via the internet address

`http://tejo.rz.uni-rostock.de/gserver/index.html`

Our intention is to keep the knowledge base up–to–date and extend it by new important classes.

Peter Tittmann, Mittweida (Germany)

Partitions and Network Reliability

Let G be a finite undirected graph. The edges of $G = (V, E)$ are assumed to fail independently with known probabilities. The vertices are perfectly reliable. A reliability measures for G is the probability $R(G, K)$ that all vertices belonging to a specified set $K \subseteq V$ are connected with each other by paths of operating edges. The special case where K includes all vertices of G is called all-terminal reliability $R(G)$. If all edges of G fail with identical probability q then $R(G)$ is a polynomial in q which can be obtained by an evaluation of the Tutte polynomial of G. The problem of connectedness in graphs is naturally related to partitions of the vertex set of the graph.

In this paper we show how the partition lattice of the vertex set can be employed to define new reliability measures which permit a more general approach to connectedness in graphs. We use the incidence algebra of the partition lattice to show that the all-terminal reliability and K-terminal reliability are closely related. As an application of the presented approach we derive an explicit formula for the K-terminal reliability polynomial of the complete graph as a sum ranging over integer partitions. A new derivation of Buzacott's node partition formula is presented.

Sven de Vries, Munich (Germany)
Peter Gritzmann

Polyhedral Methods for Discrete Tomography

We focus on the algorithmic problem of recovering finite lattice sets from their discrete X-rays which are in effect projections counted with multiplicities. This problem arises in many practical applications. In particular, improvements in the generation and interpretation of high resolution transmission microscopy images lead to the problem of determining crystalline structures from X-ray information for certain directions.

The problem is known to be NP-hard if more than 2 X-rays are given. In spite of this, efficient algorithmic solutions have to be found for solving the practical problems. For this purpose two polyhedra are introduced and partially described.

Annegret Wagler, Berlin (Germany)

On a New Class of Extremal Perfect Graphs

A well-known technique for understanding a graph property is the investigation of extremal graphs with respect to this property. We introduce as new class of extremal perfect graphs critically perfect graphs, i.e., perfect graphs that lose their perfectness by the deletion of an arbitrary edge.
We give examples of such graphs and investigate intersections with some other subclasses of perfect graphs. Finally, we apply this knowledge to stable set polytopes associated with imperfect graphs arising by the deletion of an edge in a critically perfect graph.

Alfred Wassermann, Bayreuth (Germany)

Computer construction of simple t-designs

A successful approach to the construction of simple t-(v, k, λ)-designs with $t \geq 3$ is to prescribe a group of automorphisms, compute the corresponding Kramer-Mesner matrix $A^G_{t,k}$ and solve the resulting diophantine linear system

$$A^G_{t,k} \cdot x = (\lambda, \lambda, \ldots, \Lambda)^\top, \text{ where } x \in \{0, 1\}^n.$$

Despite the fact that no polynomial algorithm is known for the last task, the use of lattice basis reduction techniques together with l_∞-enumeration has enabled even the construction of designs with $t = 7, 8$. A complete table of the latest results is kept at

`http://www.mathe2.uni-bayreuth.de/betten/DISCRETA/Index.html`.

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