CP1

A Characterization of the Tree-Decomposition of 3-Trees That Can Be Represented as Unit Rectangle Visibility Graphs

Building on work of Dean, Ellis-Monaghan, Hamilton and Pangborn, we study unit rectangle visibility graphs (URVGs), that is, graphs whose vertices can be represented by axis-aligned unit squares in the plane and whose adjacencies are represented by vertical or horizontal visibility between squares. The former work characterizes trees that are URVGs. We characterize the tree-decompositions of 3-trees that are URVGs as those whose tree decompositions belong to a class of trees closely related to caterpillars of maximum degree 4.

Joan P. Hutchinson
Macalester College
Department of Mathematics
hutchinson@macalester.edu

Alice M. Dean
Skidmore College
adean@skidmore.edu

CP1

Minkowski Fonctionals on a Hexagonal Tesselation

Any pattern in a cubic tessellation can be decomposed into open elements (vertices, edges, faces, cubes...). The functionals F_l which count the number of elements O_l are additive, motion invariant and monotonically increasing. Any additive and motion-invariant functional must be a linear combination of the F_l. It is already known that F_l can be used to determine the typical geometric quantities. We have shown that this approach can be extended to an hexagonal tessellation.

Isabelle Blasquez
Limoges University
isabelle.blasquez@unilim.fr

Pierre fournier
LICN-IUT du Limousin
pierre.fournier@unilim.fr

Jean-Franois Poiraudeau
Limoges University, LICN-IUT
jean-francois.poiraudeau@unilim.fr

CP1

Convex Subdivisions with Low Stabbing Numbers

It is shown that for every subdivision of the d-dimensional Euclidean space, $d \geq 2$, into n convex cells, there is a straight line that stabs at least $\Omega((\log n/\log\log n)^{1/(d-1)})$ cells. In other words, if a convex subdivision of d-space has the property that any line stabs at most k convex cells, then the subdivision consists of at most $\exp(O(k^{d-1}\log k))$ cells. This bound is best possible apart from a constant factor. It was previously known only in the case $d = 2$.

Csaba D. Toth
University of Calgary
cdtoth@ucalgary.ca

CP1

Large Quadrant - Depth

Let P be a set of n points in R^d. We make an attempt to characterize the set of all pairs (α, β) such that there always exists a point z and two opposite orthants, determined by the axes parallel hyperplanes through z, such that one contains at least αn points of P and the other at least βn points of P. We explore both the case where z is required to belong to the set P and also the general case where z may be any point in R^d. Some generalizations of this problem are also considered.

Itay Ben-Dan
Math Dept. Technion
Haifa 32000 Israel
itay@gmail.com

Stefan Felsner
Technical University of Berlin
Institute for Mathematics
felsner@math.tu-berlin.de

Rom Pinchasi
Math Dept. Technion
Haifa 32000 Israel
room@math.technion.ac.il

Ran Ziv
Tel-Hai Academic College
Upper Galilee, Israel
ranziv@telhai.ac.il

CP2

The A_4-Structure of a Graph

In analogy with the P_4-structure of a graph, we define the A_4-structure of a graph G to be the 4-uniform hypergraph on $V(G)$ whose edges are vertex subsets inducing alternating 4-cycles. We present several analogues for A_4-structure of known results on P_4-structures, and in doing so we provide further motivation for the work of R. Tyshkevich on canonical decomposition of a graph [Decomposition of graphical sequences and unigraphs. Discrete Math. 220 (2000), no. 1-3, 201–238].

Michael D. Barrus
University of Illinois at Urbana-Champaign
mbarrus2@uiuc.edu

Douglas B. West
Univ of Illinois - Urbana
Department of Mathematics
west@math.uiuc.edu

CP2

Grunbaum Colorings of Toroidal Triangulations

Grunbaum's Conjecture, that every triangulation of an orientable surface has a 3-edge-coloring such that each facial triangle receives three colors, was recently disproven for surfaces of genus 5 and higher by Kochol. In contrast, we show that the conjecture holds for toroidal triangulations that do not have chromatic number 5.

Sarah-Marie Belcastro
Smith College
Hampshire College Summer Studies in Mathematics
smbelcas@toroidalsnark.net

Michael O. Albertson
Smith College
albertson@math.smith.edu

Hannah Alpert
University of Chicago
ecaviv@gmail.com

Ruth Haas
Smith College
rhaas@email.smith.edu

CP2

The Kuratowski Covering Conjecture for Graphs of Order < 10

Kuratowski proved that a finite graph embeds in the plane if it does not contain a subdivision of either K_5 or $K_{3,3}$, called Kuratowski subgraphs. A generalization of this result to all nonorientable surfaces says that a finite graph embeds in the nonorientable surface of genus $\tilde{g}$ if it does not contain $\tilde{g}+1$ Kuratowski subgraphs such that the union of each pair of these fails to embed in the projective plane, the union of each triple of these fails to embed in the Klein bottle if $\tilde{g} \geq 2$, and the union of each triple of these fails to embed in the torus if $\tilde{g} \geq 3$. We prove this conjecture for all graphs of order < 10.

Suhkjin Hur
Department of Mathematics
The Ohio State University
sjin@math.ohio-state.edu

CP3

Totally Greedy Coinsets and Greedy Obstructions

A coin set $C = (a_1, a_2, \ldots, a_k)$ is a list of positive integers with $a_k > a_{k-1} > \ldots > a_2 > a_1$, where a_1 is always set to be 1. Pearson has provided a polynomial time algorithm for determining whether a coinset is greedy, that is when a simple greedy change-making algorithm that always chooses the largest denomination coins possible, will also produce the fewest number of coins in change. We consider a stricter properties on coin sets, called total greediness, which requires that all initial subsequences of the coinset also be greedy, and present a simple property that makes it easy to test if a coinset is totally greedy. Finally, we begin to explore the theory of greedy obstructions– those coinsets that cannot be extended to greedy coinsets by the addition of coins in larger denominations.

Robert Cowen
Queens College, CUNY
robert.cowen@gmail.com

Lenore Cowen
Dept. of Computer Science
Tufts University
cowen@cs.tufts.edu

Arthur Steinberg
Queens College, CUNY
athur.steinberg@qc.cuny.edu

CP3

A Discrete Optimization Formulation for the Minimum Cost Vaccine Formulary Selection Problem

As the complexity of the United States Recommended Childhood Immunization Schedule increases, a combinatorial explosion of choices is being presented to public health policy makers and pediatricians. A discrete optimization problem, termed the General Minimum Cost Vaccine Formulary Selection Problem (GMCVFSP), is presented, which models a general childhood immunization schedule. Exact algorithms and heuristics for GMCVFSP are discussed. Computational results are also reported. The results reported provide fundamental insights into the structure of the GMCVFSP model.

Shane Hall
AFIT
shane.hall@afit.edu

Sheldon H. Jacobson
University of Illinois
Dept of Computer Science
shj@uiuc.edu

Edward Sewell
Southern Illinois University Edwardsville
esewell@siue.edu

CP3

A Min-Max Theorem on a Class of Bipartite Graphs with Applications

We prove a theorem on the class of bipartite graphs that do not contain any induced cycles on exactly six vertices. Using this, we show that the size of a largest induced matching equals the size of a smallest cover with chain subgraphs for the class of chordal bipartite graphs. Further, we show that a largest induced matching and a smallest cover with chain subgraphs can be found in polynomial time for the class of chordal bipartite graphs, and also present efficient algorithms for a subclass of chordal bipartite graphs. These problems are NP-hard for general bipartite graphs and our work generalizes previously known results.

R. Sritharan, Atif Abueida, Arthur Busch
The University of Dayton
srithara@notes.udayton.edu,
atif.abueida@notes.udayton.edu,
arthur.busch@notes.udayton.edu

CP4

Non-Cover Generalized Mycielski, Kneser, and Schrijver Graphs

A graph is said to be a cover graph if it is the underlying graph of the Hasse diagram of a finite partially ordered set. We prove that the gereralized Mycielski graphs of an odd cycle, Kneser graphs KG(n, k), and Schrijver graphs SG(n, k) are not cover graphs when $n \geq 2k + 2$.

Chen-Ying Lin
Department of Computer Science and Information Engineering,
Shu-Te University, Kaohsiung 824, Taiwan
lincy@mail.stu.edu.tw

Ko-Wei Lih
Institute of Mathematics, Academia Sinica, Taipei
makwlih@sinica.edu.tw

Li-Da Tong
National Sun Yat-sen University, Taiwan
ldtong@math.nsysu.edu.tw

CP4
On the Multi-Dimensional Frobenius Problem

We consider the problem of finding maximal (in an appropriate partial order) solutions g to the linear Diophantine system $Mx = g$. We extend past work and prove several reduction formulas. This is work done by undergraduates in an REU program.

Vadim Ponomarenko
San Diego State University
Department of Mathematics and Statistics
vadim123@gmail.com

Jeffrey Amos
Kansas State University
jmamos1984@gmail.com

Charles Chen
Harvard University
chen33@fas.harvard.edu

Olga Lepigina
Colorado College
ol2107@columbia.edu

Timur Nezhmetdinov
Lehigh University
tin209@lehigh.edu

Darren Ong
Texas Christian University
d.ong@tcu.edu

Matthew Richer
Arizona State University
matthew.richer@asu.edu

Laura Zirbel
Loyola Marymount University
laurazirbel@gmail.com

CP4
Fractional Weak Discrepancy, Interval Orders, and Forbidden Configurations

The *fractional weak discrepancy* $wd_F(P)$ of a poset $P = (V, \prec)$ is the minimum nonnegative k for which there exists a function $f : V \to \mathbf{R}$ satisfying (i) if $a \prec b$ then $f(a) + 1 \leq f(b)$ and (ii) if $a \parallel b$ then $|f(a) - f(b)| \leq k$. An $\mathbf{r}+\mathbf{s}$ is a disjoint union of two chains with r and s elements, respectively. Semiorders, which contain no induced $\mathbf{2}+\mathbf{2}$ or $\mathbf{3}+\mathbf{1}$, were characterized by their fractional weak discrepancy in Shuchat, Shull, and Trenk, *ORDER*, 23:51–63, 2006. Here we generalize this result to describe the range of values of $wd_F(P)$ based on whether or not P contains certain induced $\mathbf{r}+\mathbf{s}$ configurations. For example, we find the range of $wd_F(P)$ for interval orders with no induced $\mathbf{n}+\mathbf{1}$.

Alan Shuchat
Mathematics Department
Wellesley College
ashuchat@wellesley.edu

Randy Shull
Department of Computer Science
Wellesley College
rshull@wellesley.edu

Ann N. Trenk
Wellesley College
atrenk@wellesley.edu

CP4
The Fractional Weak Discrepancy of Split Semiorders

The *fractional weak discrepancy* $wd_F(P)$ of a poset $P = (V, \prec)$ is the minimum nonnegative k for which there exists a function $f : V \to \mathbf{R}$ satisfying (i) if $a \prec b$ then $f(a) + 1 \leq f(b)$ and (ii) if $a \parallel b$ then $|f(a) - f(b)| \leq k$. In this talk we extend previous results on the range of $wd_F(P)$ for semiorders to split semiorders (also known as unit point-core bitolerance orders). In particular, we prove that for such posets the range is the set of rationals r/s for which $s > 0$ and $s - 1 \leq r < 2s$.

Randy Shull
Department of Computer Science
Wellesley College
rshull@wellesley.edu

Alan Shuchat
Mathematics Department
Wellesley College
ashuchat@wellesley.edu

Ann N. Trenk
Wellesley College
atrenk@wellesley.edu

CP5
A Generalization of the Laplacian Characteristic Polynomial

A generalization of the characteristic polynomial of the Laplacian matrix of a simple graph is proposed, from which the Laplacian characteristic poly for the graph as well as for its complement can be derived as special cases. Also, graphs with the same generalised characteristic polynomial are discussed.

Biswajit Deb
SMIT, SIKKIM, INDIA
Pin. 737132
biswajit_deb1@rediffmail.com

Sukanta Das
SMIT, SIKKIM, India
sukanta1003@gmail.com

CP5
On Middle Cube Graphs

The middle cube graph of the cube Q_{2k+1} contains vertices whose binary representation has either $\binom{2k+1}{k}$ or $\binom{2k+1}{k+1}$ number of 1's and their associated edges. This family of graphs has been proposed as model of interconnection network because of its properties. The middle cube graph can be obtained from the well-known odd graphs. Here we study some of their properties under the light of the theory of distance regular graphs.

Lali Barriere, Cristina Dalfó, Miquel ngel Fiol
Depart. Matemàtica Aplicada IV
Universitat Politècnica de Catalunya
lali@ma4.upc.edu, cdalfo@ma4.upc.edu, fiol@ma4.upc.edu

Margarida Mitjana
Depart. Matemàtica Aplicada I
Universitat Politècnica de Catalunya
margarida.mitjana@upc.edu

CP5
Equivalences on Graph Dynamical Systems (GDS)

GDS are discrete dynamical systems over graphs Y. For asynchronous GDS the dynamical system map is specified using a permutation of the vertices of Y. Building on functional equivalence of asynchronous GDS, which is characterized through the acyclic orientations of Y, we present new results showing how orbit equivalence of GDS is captured by group actions on acyclic orientations, and how the equivalence classes are enumerated through the Möbius invariant of Y. The connection to Coxeter theory will be shown.

Henning S. Mortveit
Assistant Professor/Senior Research Associate
Virginia Tech
Henning.Mortveit@gmail.com

CP5
Spectral Classification of Regular Graphs and Hamiltonian Cycles

We present new results on the connection between the determinant of a matrix function of subgraphs and the longest cycles in a given graph. We show that certain functionals dependent on graph spectrum exhibit a fractal-like, multifilar structure, and explain this phenomenon using the Ihara-Selberg formula and geodesics. This structure separates non-Hamiltonian regular graphs into bridge and hard camouflaged graphs. A new recursive formula for the cardinality of regular bridge graphs will also be presented.

Giang T. Nguyen
University of South Australia
giang.nguyen@unisa.edu.au

CP5
Subgraphs of Singular Graphs

Characterization of singular graphs can be reduced to the non-trivial solutions of a system of linear homogeneous equations $\mathbf{Ax} = \mathbf{0}$ for the 0-1 adjacency matrix $\mathbf{A}$. A graph G is singular of nullity $\eta(G) \geq 1$, if the dimension of the nullspace $\ker(\mathbf{A})$ of its adjacency matrix $\mathbf{A}$ is $\eta(G)$. We determine necessary and sufficient conditions for a graph to be singular in terms of admissible induced subgraphs.

Irene N. Sciriha
University of MALTA
isci1@um.edu.mt

CP6
The Coloring Graph

Two colorings of a graph, G, are isomorphic if by permuting the colors in one of them, we can obtain the other. The set of nonisomorphic colorings of G is the set of isomorphism classes of proper colorings. Define the graph of nonisomorphic colorings of G, I(G), to have vertex set equal the set of nonisomorphic colorings of G, with an edge between two colorings if they are isomorphic on V(G-x for some x in V(G). In this talk we explore properties of I(G).

Ruth Haas
Smith College
rhaas@email.smith.edu

Ina Petkova
Columbia University
ina@math.columbia.edu

CP6
Bounding the Chromatic Number of Claw-Free Graphs

Reed conjectured that for any graph, $\chi \leq \lceil \frac{1}{2}(\Delta + 1 + \omega) \rceil$, where χ, Δ, and ω are the chromatic number, maximum degree, and clique number respectively. This conjecture has recently been proven for line graphs and quasi-line graphs. We extend these results, proving the conjecture for all claw-free graphs and discussing a stronger (and sometimes more manageable) version of the conjecture.

Andrew D. King, Bruce Reed
McGill University
aking6@cs.mcgill.ca, breed@cs.mcgill.ca

CP6
Graph Partitions

Let H be a graph with vertex set $V(H) = \{1, 2, \ldots, n\}$, and let $C_1, C_2, \ldots, C_n$ be sets of graphs. An $(H; C_1, C_2, \ldots, C_n)$-partition of a graph G is an ordered partition $(V_1, V_2, \ldots, V_n)$ of $V(G)$ such that, for each i, the subgraph of G induced by V_i belongs to C_i and, further, there is an edge joining a vertex in V_i to a vertex in V_j only if ij is in $E(H)$. When each set C_i equals $\{\overline{K_n} : n = 0, 1, 2, \ldots\}$ this concept coincides with the usual notion of homomorphism of G to H. If, in addition, H is complete, it coincides with the usual notion of n-colouring of G. We describe polynomial time algorithms for the case where H is triangle-free and each set C_i is a "starter matrix class" of graphs – a large collection of graphs classes that includes cliques, stars, complete k-partite graphs, and graphs with a dominating vertex. We also give NP-completeness results in a variety of cases when H contains a triangle, for example when each set C_i is the set of k-partite graphs.

Gary Macgillivray
Mathematics and Statistics
University of Victoria
gmacgill@uvic.ca

Peter Dukes
University of Victoria, Canada
dukes@math.uvic.ca

Steve Lowdon
Mathematics and Statistics
University of Victoria
slowdon@math.uvic.ca

CP6

Complexity of Generalised Colourings of Chordal Graphs

In our contribution, we investigate generalised colouring problems in the class of chordal graphs. In particular, we focus on colouring problems in which the colour classes are avoiding particular types of forbidden induced subgraphs. These include for instance problems like split colourings, polar colourings, subcolourings and many others. We describe recent complexity results for cases with small forbidden induced subgraphs and outline possible extensions of these results.

Juraj Stacho
Simon Fraser University
jstacho@cs.sfu.ca

CP7

Graphs without a C_4 or a Diamond

In general, it is not clear how to generalize results on chordal graphs to C_4-free graphs and there are a number of open questions regarding C_4-free graphs. We consider the class of (C_4, diamond)-free graphs. We provide an efficient recognition algorithm, and count the number of maximal cliques and the number of n-vertex labeled graphs. We also give an efficient algorithm for finding a largest clique in the more general class of (house, diamond)-free graphs.

Elaine M. Eschen
Lane Department of CSEE,
West Virginia University
Elaine.Eschen@mail.wvu.edu

Chinh Hoang
Wilfrid Laurier University
Dept of Physics and Computing Science
choang@wlu.ca

Jeremy Spinrad
Vanderbilt University
spin@vuse.vanderbilt.edu

R. Sritharan
University of Dayton
sri.sritharan@notes.udayton.edu

CP7

Simultaneously Chordal Graphs

Two graphs, G_1 and G_2, sharing some vertices S, are *simultaneously chordal* if we can add edges E' between $G_1 - S$ and $G_2 - S$ to create a chordal graph $G_1 \cup G2 \cup E'$. Equivalently, G_1 and G_2 have an intersection representation as subtrees of one common tree. This concept is related to simultaneous planar embeddings and to the graph sandwich problem. In contrast with the graph sandwich problems, graph simultaneity problems are in P for many interesting properties. We give an efficient algorithm for simultaneous chordality.

Krishnam Raju Jampani, Anna Lubiw
University of Waterloo
Canada
krjampan@uwaterloo.ca, alubiw@cs.uwaterloo.ca

CP7

How Vertex Elimination Can Overachieve

Simplicial ('perfect) elimination orderings of chordal graphs enjoy many advantages that overlap and are easily confused—for instance, the total unimportance of the choices among simplicial vertices (removing the scheming from elimination schemes). What assures this bonus when 'simplicial is replaced with an arbitrary vertex property $\phi(v)$? Or, what guarantees the existence of choices at every step in ϕ-elimination? The graph metatheory of vertex elimination involves suitable distinctions, linked by simple theorems and delineating counterexamples.

Terry McKee
Wright State University
Department of Mathematics & Statistics
terry.mckee@wright.edu

CP7

Local Steiner Convexity in Graphs

Let G be a connected graph and $S \subseteq V(G)$. A Steiner tree T for S is a minimum subtree of G with $S \subseteq V(T)$. The Steiner distance of S is $|E(T)|$. A set $S \subseteq V(G)$ is g_k-convex, if for every k-subset $R \subseteq S$, every Steiner tree T for R satisfies $V(T) \subseteq S$. Considering three local g_3-convexities, we characterize graphs satisfying either of the first two and determine some necessary and some sufficient conditions for a graph to satisfy the third.

Morten H. Nielsen
University of Winnipeg
m.nielsen@uwinnipeg.ca

Ortrud R. Oellermann
The University of Winnipeg
o.oellermann@uwinnipeg.ca

Michael A. Henning
University of KwaZulu-Natal
henning@ukzn.ac.za

CP8

Some Non-Simple Forbidden Configurations and Design Theory

Let k, l, m, q be given. We let $f(m, k, l, q)$ denote the maximum number of subsets of $\{1, 2, \ldots, m\}$ in a family $\mathcal{F}$ so that we cannot find q sets $A_1, A_2, \ldots, A_q \in \mathcal{F}$ and $k + l$ elements $a_1, a_2, ..., a_{k+l} \in \{1, 2, \ldots, m\}$ so that each of the q sets A_i contains the k elements a_1, a_2, ..., a_k and does not contain the l elements a_{k+1}, a_{k+2}, ..., a_{k+l}. We are able to compute $f(m, 1, 1, q)$, $f(m, 2, 1, q)$ and $f(m, 2, 2, q)$ exactly for large m. For example, the natural construction for $k = 2$, $l = 1$ is to take all sets of size 0, 1, 2, m and also the sets of size 3 corresponding to a simple triple system of $\lambda = q - 2$ (which exists by a result of Dehon, 1983) and we are able to show for large m that indeed $f(m, 2, 1, q) = \binom{m}{0} + \binom{m}{1} + \binom{m}{2} + \frac{q-2}{3}\binom{m}{2} + \binom{m}{m}$.

Richard P. Anstee
Mathematics Department
University of British Columbia
anstee@math.ubc.ca

Farzin Barekat
Mathematics Deaprtment, UBC

farzin_barekat@yahoo.com

CP8

About Convexity of One Function from Coding Theory

We complete the proof of upper bound for the multiple packing in $q-$ary Hamming space.

Vladimir Blinovsky
Institute of Information Transmission Problems
vblinovs@math.uni-bielefeld.de

CP8

Avoiding Partial Latin Squares

Let P be an $n \times n$ array of symbols. P is called avoidable if for every set of n symbols there is an $n \times n$ Latin square L on these symbols so that corresponding cells in L and P differ. We give a short argument that shows all partial Latin squares of order at least 4 are avoidable. We also show, if time permits, that a partial generalized sudoku square of order n^2 can be avoided by a generalized sudoku square of order n^2.

Jaromy S. Kuhl
University of West Florida
jkuhl@uwf.edu

Tristan Denley
University of Mississippi
tdenley@olemiss.edu

CP8

Perfect $T(G)$ Triple Systems when G is a Matching

A $T(G)$ triple is formed by taking a graph G and replacing every edge with a 3-cycle, where all of the new vertices are distinct from all others in G. An edge-disjoint decomposition of $3K_n$ into $T(G)$ triples is called a $T(G)$ triple system. Finally, suppose that G partitions K_n. If we can decompose K_n into copies of the graph G, where we can form a $T(G)$ triple from each graph in the decomposition and produce a partition of $3K_n$, then the resulting $T(G)$ triple system is called *perfect*. The set of positive integers n, for which a decomposition of $3K_n$ into a perfect $T(G)$ triple system exists is called the *spectrum*. The spectra for all graphs on 4 or fewer vertices have been completely determined by Billington, Küçükçifçi, Lindner, and Rosa. However, the spectra for graphs on arbitrary numbers of vertices is still an open problem. In this talk, I will discuss joint work with Danny Dyer on determining the spectrum when G is an arbitrary matching. In particular I will identify infinite families for which we have determined the spectra and illustrate a relationship with generalized extended Skolem sequences of multiplicity 3.

Josh Manzer
Memorial University of Newfoundland
manzer@math.mun.ca

CP8

Combinatorial Constructions for Optimal Two-Dimensional Optical Orthogonal Code

Optical orthogonal codes (OOCs) have been designed for OCDMA. An one dimensional (1-D) optical orthogonal code (1-D OOC) is a set of one-dimensional binary sequences having good auto and cross-correlations. One limitation of 1-D OOC is that the length of the sequence increases rapidly when the number of users or the weight of the code is increased, which means large bandwidth expansion is required if a big number of codewords is needed. To lessen this problem, two-dimensional (2-D) coding (also called multiwavelength OOCs) was invested. An two dimensional (2-D) optical orthogonal code (2-D OOC) is a set of $u \times v$ matrix with $(0, 1)$ elements having good auto and cross-correlations. Recently many researchers are working on constructions and designs of 2-D OOCs. In this paper, we shall reveal the combinatorial properties of 2-D OOCs and give an equivalent combinatorial description of 2-D OOC. Based on this, we are able to use combinatorial methods to obtain many optimal 2-D OOCs.

Ruizhong Wei
Department of Computer Science
Lakehead University
rwei@lakeheadu.ca

CP9

Strong Cayley Graphs, Weak Cayley Graphs and Non-Cayley Graphs

In this talk, I will first discuss strong Caley graphs and weak Cayley graphs. I will then present examples of such graphs, as well as non-Cayley graphs.

Yuqing Chen
Department of Mathematics and Statistics
Wright State University
yuqing.chen@wright.edu

CP9

Independent Domination Critical and Bicritical Graphs

A graph is independent domination critical if the removal of any vertex decreases the independent domination number and it is independent domination bicritical if the removal of any two vertices reduces the independent domination number. We present new results in this area, including various construction methods and diameter results.

Michelle Edwards
University of Victoria
Department of Mathematics and Statistics
michelle@math.uvic.ca

Arthur Finbow
Saint Mary's University
Department of Mathematics and Computing Science
art.finbow@smu.ca

Gary MacGillivray
University of Victoria
Department of Mathematics and Statistics
gmacgill@math.uvic.ca

CP9

Graceful Directed Graphs

A graph G consists of a set of vertices and a set of edges. If a nonnegative integer f(v) is assigned to each vertex v of G then the vertices of G are said to be labeled. G is itself a labeled graph if each edge e=uv is given the value f(uv) = f(u)*f(v), where * is a binary operation. In literature one can find the binary operation * as addition, multiplication, modulo addition or absolute difference or modulo subtraction. Graph labelings, where the vertices and edges are assigned, real values subject to certain conditions, have often been motivated by their utility to various applied fields and their intrinsic mathematical interest (logico mathematical). A directed graph D with n nodes and e arcs, no self-loops and multiple edges is labeled by assigning to each node a distinct element from the set Ze+1 = 0,1,2,,e. An arc (x,y) from node x to y is labeled with ?(xy)= (?(x)-?(y))(mod (e+1)), where ?(x) and ?(y) are the values assigned to the nodes x and y. A labeling is a graceful labeling of D if all ?(xy) are distinct. Then D is called a graceful digraph. In this talk we discuss about graceful labelings of directed graphs and their applications to algebra (sequenciable cyclic groups, complete mappings and neofields).

Suresh M. Hegde
national Institute of Technology Karnataka
Surathkal
smhegde59@yahoo.com

CP9

Triangle-Free Graphs and Greedoids

A matching is uniquely restricted if its saturated vertices induce a subgraph having a unique perfect matching. S is a local maximum stable set of G, and we write $S \in \Psi(G)$, if S is a maximum stable set of $G[N[S]]$. Nemhauser and Trotter Jr. proved that any $S \in \Psi(G)$ is a subset of a maximum stable set of G. We demonstrate that if G is triangle-free, then $\Psi(G)$ is a greedoid iff all its maximum matchings are uniquely restricted and $G[N[S]]$ is a König-Egerváry graph for any $S \in \Psi(G)$.

Vadim E. Levit
Ariel University Center of Samaria and Holon Inst. of Tech.
Dept. of Computer Science & Mathematics
levitv@ariel.ac.il

Eugen Mandrescu
Department of Computer Science
Holon Institute of Technology
eugen_m@hit.ac.il

CP9

Labeling Graphs with Three Levels of Constraints

Motivated by the channel assignment problem, a graph labeling with conditions that depend on the distance between vertices (called distance labeling) has been proposed and studied by many authors. In previous studies, these distance labelings with two constraints have been considered. In this talk, we will consider distance labelings with three constrains. In particular, given a graph $G = (V, E)$ and positive integers d_1, d_2, d_3, an $L(d_1, d_2, d_3)$-labeling is an assignment $f : V \to \{0, 1, \cdots\}$ such that $|f(u) - f(v)| \geq d_i$ whenever the distance vertices u and v is i in G, for $i = 1, 2, 3$. We seek a smallest integer k (denoted by $\lambda(G; d_1, d_2, d_3)$ so that there is an $L(d_1, d_2, d_3)$-labeling on G with the maximum value k. We study this value on several classes of graphs.

Roger Yeh
Dept. of Applied Math., Feng Chia University
rkyeh@math.fcu.edu.tw

Honya Liao, Cian-Hui Yang
Dept. of Applied Math., Feng Chia Univ.
rgciap@gmail.com, djmrkye@yahoo.com.tw

CP10

Subdivided Graphs As Isometric Subgraphs of Hamming Graphs

Isometric subgraphs of Hamming graphs (resp. hypercubes) are called *partial Hamming graphs* (resp. *partial cubes*). Partial cubes have first been investigated in [Graham Pollack, On the addressing problem for loop switching,1971] and [Djokovič, Distance preserving subgraphs of the hypercubes,1973]. In this talk we present structural characterizations of partial Hamming graphs. It is proven that given G a subdivision of a clique K_n $(n \geq 1)$, G is isometrically embeddable in a Hamming graph if and only if G is a partial cube or $G = K_n$. The characterization for subdivided wheels is also obtained.

Laurent Beaudou
Institut Fourier
laurent.beaudou@ujf-grenoble.fr

Sylvain Gravier
CNRS – Institut Fourier
ERTE Maths a Modeler
sylvain.gravier@ujf-grenoble.fr

Kahina Meslem
LAID3 – USTHB
Institut Fourier
kahina_m2000@yahoo.fr

CP10

A Formula for the Kirchhoff Index

We show here that the Kirchhoff index of a network is the average of the Wiener capacities of its vertices. Moreover, we obtain a closed-form formula for the effective resistance between any pair of vertices when the considered network has some symmetries which allows us to give the corresponding formulas for the Kirchhoff index. In addition, we find the expression for the Foster's n-th Formula.

Angeles Carmona, Enrique Bendito, Andres Encinas, Jose Gesto
Department of Applied Mathematics III
Universitat Politècnica de Catalunya
angeles.carmona@upc.es, enrique.bendito@upc.edu, andres.marcos.encinas@upc.edu, jose.manuel.gesto@upc.edu

CP10

Pizza Delivery: 2-Stop-Return Distances in Graphs

A delivery person must leave a central location, deliver packages at various addresses, and return by the most efficent route. This motivates the following definition. Given a set of $k+1$ distinct vertices $v, v_1, v_2, \ldots, v_k$ in a simple graph G, the *k-stop-return* distance from v to $\{v_1, v_2, \ldots, v_k\}$ is defined to be

$$d_{ks}(v, v_1, v_2, \ldots, v_k) = min_{\mathcal{P}(\mathcal{S})} \left(d(v, v_1) + d(v_1, v_2) + \ldots + d(v_k, v) \right),$$

where $\mathcal{P}(\mathcal{S})$ is the set of all permutations of $\{v_1, v_2, \ldots, v_k\}$. We consider some questions related to the 2-stop-return radius, diameter, center, and periphery.

Grady Bullington, Linda Eroh

University of Wisconsin, Oshkosh
bullingt@uwosh.edu, eroh@uwosh.edu

Ralucca M. Gera
Naval Postgraduate School
rgera@nps.edu

Steven J. Winters
University of Wisconsin Oshkosh
winters@uwosh.edu

CP10
Minimum Size of a Graph of Given Diameter

We determine the minimum size of a graph of fixed diameter and fixed minimum degree. This answers a question of J.A. Bondy and U.S.R. Murty, *Extremal Graphs of diameter two with prescribed minimum degree*, Studia Sci. Math. Hungar. **7** (1972), 239-241. We relate this result to a problem in graph pebbling.

Peter Dankelmann
University of KwaZulu-Natal
Durban, South Africa
dankelma@ukzn.ac.za

John Schmitt
Middlebury College
Middlebury, VT
jschmitt@middlebury.edu

Lutz Volkmann
Lehrstuhl II fur Mathematik
Aachen, Germany
volkm@math2.rwth-aachen.de

CP10
The (a,b)-Forcing Geodetic Graphs

For every pair of vertices u, v in a graph, a u-v geodesic is a shortest path from u to v. For a graph G, let $I_G[u, v]$ denote the set of all vertices lying on a u-v geodesic, and for $S \subseteq V(G)$, let $I_G[S]$ denote the union of all $I_G[u, v]$ for all $u, v \in S$. A set $S \subseteq V(G)$ is a geodetic set if $I_G[S] = V(G)$. The geodetic number $g(G)$ of a graph G is the minimum cardinality of a geodetic set in G. A subset $F \subseteq V(G)$ is called a forcing subset of G if there exists a unique minimum geodetic set containing F. A forcing subset F is critical if every proper subset of F is not a forcing subset. The cardinality of a minimum critical forcing subset in G is called the forcing geodetic number $f(G)$ of G and the cardinality of a maximum critical forcing subset in G is called the upper forcing geodetic number $f^+(G)$ of G. If G is a graph with $f(G) = 0$, then G has a unique minimum geodetic set; that is, $f^+(G) = 0$. In the paper, we prove that, for any nonnegative integers a, b and c with $1 \leq a \leq b \leq c-2$ or $4 \leq a+2 \leq b \leq c$, there exists a connected graph G with $f(G) = a$, $f^+(G) = b$, and $g(G) = c$. This result solves a problem of Zhang in [The upper forcing geodetic number of a graph, *Ars Combinatorica* **62** (2002), 3-15].

Li-Da Tong
National Sun Yat-sen University, Taiwan
ldtong@math.nsysu.edu.tw

CP11
Periodicity and Other Structure in a Colorful Family of Nim-like Arrays

We study aspects of the combinatorial and graphical structure shared by a certain family of recursively generated arrays related to the operation of Nim-addition. In particular, these arrays display periodic behavior along rows and diagonals. We explain how various features of computer-generated graphics depicting these arrays are reflections of the theorems we prove.

Lowell Abrams
Department of Mathematics
The George Washington University
labrams@gwu.edu

Dena Morton
Department of Mathematics and Computer Science
Xavier University
morton@xavier.edu

CP11
Periods, Partial Words, and a Result of Guibas and Odlyzko

A well known and unexpected result of Guibas and Odlyzko states that the set of all periods of a word is independent of the alphabet size. We provide an algorithm that given a *nonspecial* partial word u, or word with "do not know" symbols or "holes," computes a binary partial word v sharing the same sets of periods and weak periods as u, and satisfying $H(u) \supset H(v)$ where $H(u), H(v)$ denote the sets of holes of u, v.

Francine Blanchet-Sadri
University of North Carolina
blanchet@uncg.edu

Brian Shirey
NC State University
Department of Computer Science
bjshirey@ncsu.edu

CP11
Hsiao-Code Check Matrices and Recursively Balanced Matrices

The key step of generating the well-known Hsiao code is to construct a $\{0, 1\}$-check-matrix in which each column contains the same odd-number of 1's and each row contains the same number of 1's or differs at most by one for the number of 1's. and no two columns are identical in the matrix. Here, we focus on how to practically generate the check matrix of Hsiao codes. We have modified the original algorithm to be more efficient and effective.

Li Chen
University of the District of Columbia
lchen@udc.edu

CP12
Construction of Transformation and Summation Formulas Using Symbolic Operator Approach and Their Applications

Here we present the construction of pairs of transformation and expansion formulas by using a kind of symbolic operator method and generalized Eulerian fractions. The applications of the formulas for various types of power series to the computational number theory are also discussed.

Tian-Xiao He
Illinois Wesleyan University
the@iwu.edu

CP12

Minimal Tile and Bond-Edge Types for Self-Assembling DNA Graphs

We examine a model for self-assembling DNA graphical complexes using tiles of branched DNA molecules with free sticky ends. We address determining the minimum number of tile and bond edge types necessary to create a given graph under three different scenarios: 1. Where the incidental creation of complexes of smaller size than the target graph is acceptable; 2. Where the incidental creation of complexes the same size as the target graph is acceptable, but not smaller complexes; 3. Where no complexes the same size or smaller than the target graph are acceptable. In each of these cases, we find bounds for the minimum and maximum number of tile and edge types that must be designed and give specific minimum values for common graph classes (complete, bipartite, trees, regular, etc.). For these classes of graphs, we provide either explicit descriptions of the set of tiles achieving the minimum number of tile and bond edge types, or efficient algorithms for generating the desired set.

Greta Pangborn
Saint Michael's College
gpangborn@smcvt.edu

Laura Beaudin
Saint Michaels College
lbeaudin@smcvt.edu

Joanna Ellis-Monaghan
Saint Michaels College
Department of Mathematics
jellis-monaghan@smcvt.edu

Natasha Jonoska
University of South Florida
Department of Mathematics
jonoska@math.usf.edu

Dave Miller
Saint Michaels College
dmiller@smcvt.edu

CP12

The Solution of Combinatorial Problems Using SAT

The satisfiability problem (SAT) has been very well explored. Based on very efficient parallel algorithms for its solution, it will be shown that many combinatorial problems can be transformed into satisfiablity problems and solved using these developed algorithms. The approach is constructive and very general, no research procedures are involved, the results are always complete. It can be concluded that the solution algorithms for SAT can be used (in the sense of NP-completeness) for many other combinatorial problems in a very general way.

Christian Posthoff
University of The West Indies
St. Augustine Campus, Trinidad & Tobago
cposthoff@fsa.uwi.tt

Bernd H. Steinbach
Freiberg University of Mining and Technology
Institute of Computer Science
steinb@informatik.tu-freiberg.de

CP12

Meanders and Stamp Foldings: Fast Generation Algorithms

Using a permutation representation, we present fast algorithms to exhaustively list all meanders and stamp foldings. The key to the algorithms is the introducion of a data structure that allows us to efficiently determine all possible locations to insert the next meander crossing or stamp.

Joe Sawada
University of Guelph
Dept. of Computer Science
sawada@cis.uoguelph.ca

CP13

On Classification of Rhotrices As Algebraic Structures

In this paper, we presents the study of rhotrices and their classifications as algebraic structures of Groups, Semigroups, Monoids, Ring,Field,Integral domain,Principal ideal domain,Unique factorization domain and Bolean algebra. REFERENCES: [1] MOHAMMED, A.,(2007), Enrichment exercises through extension to rhotrices, International journal for Mathematical Education in Science and Techonlogy,38, 131-136. [2] AJIBADE, A. O., (2003), The concept of rhotrix for mathematical enrichment.,International journal for Mathematical Education in Science and Techonlogy, 34,175-179. [3] SANI, B.,(2004), An alternative method for multiplication of rhotrices, International journal for Mathematical Education in Science and Techonlogy, 35, 777-781. [4] ATANASSOV, K.T. and SHANNON, A.G.(1998),Matrix-tertions and matrix-noitrets:exercises in mathematical enrichment, International journal for Mathematical Education in Science and Techonlogy, 29, 898-903

Abdul Mohammed
Department of Mathematics, Ahmadu Bello University,
Zaria, Nigeria
abdulmaths@yahoo.com

CP13

Recovery of Symmetry From Ghosts

If S is a finite subset of a vector space U and $\phi : U \to V$ is an orthogonal projection onto a subspace V, then $\phi(S)$ has "ghost symmetry" if the linear automorphisms of $S \subset U$ may be recovered from the automorphisms of $\phi(S)$ and its projections. We will see some examples and consider the computational problems involved in studying this phenomenon in general

David Richter
Western Michigan University
david.richter@wmich.edu

CP13

Noncommutative Analogs of Monomial Symmetric Functions, Cauchy Identity and Hall Scalar Product.

This talk introduces noncommutative analogs of monomial symmetric functions and fundamental noncommutative symmetric functions. The expansion of ribbon Schur functions in both of these basis is nonnegative. With these functions at hand, one obtains a noncommutative Cauchy identity and can study a noncommutative scalar product implied by Cauchy identity. This scalar product seems be a correct noncommutative analog of Hall scalar product in the commutative theory.

Lenny Tevlin
Yeshiva University, New York
tevlin@yu.edu

CP14

Binary Subtrees with Few Path Labels

Let T be the rooted, perfect ternary tree of depth n. If each edge in T is assigned a label in $\{0,1\}$, then reading the labels along the edges in a path from the root of T to a leaf in T induces a path label in $\{0,1\}^n$. Let $f(T)$ be the minimum, over all perfect binary subtrees S of depth n of T, of the number of path labels that occur in S. Let $f(n)$ be the maximum, over all $\{0,1\}$-edge-labeled perfect ternary trees T with depth n, of $f(T)$. The problem of bounding $f(n)$ arose in an attack on a problem in computability theory, and seems to be combinatorially interesting in its own right. We show that $f(n)$ is at most $(c/n)2^n$ for some constant c, and that $f(n)$ is at least $(1.505)^n$ for sufficiently large n. We conclude with some open problems.

Kevin Milans
University of Illinois
milans@uiuc.edu

CP14

Cut-Edges, 1-Blocks, and Matchings in Regular Graphs of Odd Degree

A block is a *1-block* if exactly one edge joins it to the rest of the graph. For a graph G, let $b(G)$ be the number of 1-blocks, let $c(G)$ be the number of cut-edges, and let $\alpha'(G)$ be the maximum size of a matching. Let F be the family of $(2r+1)$-regular graphs with n vertices. We prove that $b(G) \leq \frac{(2r-1)n+2}{4r^2+4r-2}$ and $c(G) \leq \frac{2rb(G)-2r-1}{2r-1}$ for $G \in F$, which yields $c(G) \leq \frac{rn-(2r^2+4r+1)}{2r^2+2r-1}$. We also prove that $\alpha'(G) \geq \frac{n}{2} - \frac{rb(G)}{2r+1}$, simplifying the recent proof by Henning and Yeo that $\alpha'(G) \geq \frac{n}{2} - \frac{r}{2}\frac{(2r-1)n-1}{(2r+1)(2r^2+2r-1)}$. For large r, this bound is about $\frac{n}{2} - \frac{n}{4r}$. All the bounds are sharp, holding with equality for infinitely many n.

Suil O
University of Illinois, Urbana
suilo2@math.uiuc.edu

Douglas B. West
Univ of Illinois - Urbana
Department of Mathematics
west@math.uiuc.edu

CP14

Bounds for the Real Number Labellings and Labellings of the Triangular Lattice

The real number graph labelling is a general model of the channel assignment problem. The transmitters are represented by vertices and close transmitters are joined by edges. There are k types of edges and the level of interference is determined by non-negative parameters $p_1, ..., p_k$. The assignment of channels is represented by assigning non-negative integers to vertices in such a way that the labels of vertices joined by an edge of the i-th type differ by at least p_i. This model generalizes $L(p_1, ..., p_k)$-labellings of graphs when the labels of vertices at distance exactly d are required to differ by at least p_d. The span of a labelling is the maximal assigned label. The goal is to find a labelling with minimal span. We establish several general lower and upper bounds for real number graph labelings and apply these bounds to $L(p,q)$-labelings of the infinite triangular plane lattice. In particular, we determine the minimal spans of $L(p,q)$-labellings of the infinite triangular plane lattice for all values of p and q (solving an open problem of Griggs).

Petr Skoda
Charles University, Czech Republic
peskoj@kam.mff.cuni.cz

Daniel Kral
Charles University
kral@kam.mff.cuni.cz

CP14

On Degenerate Colorings of Graphs on Surfaces

An r-coloring of G is *degenerate* if for every $k \leq r$, the union of any k color classes induces a $(k-1)$-degenerate graph. This is a strenghtening of the notion of an acyclic coloring. We prove that every planar graph admits a degenerate 11-coloring and that every graph of maximum degree Δ has a degenerate coloring with $O(\Delta^{3/2})$ colors. The latter result is used to prove that every graph of genus g has a degenerate coloring with $O(g^{3/5})$ colors.

Simon Spacapan
University of Maribor, Slovenia
Simon Fraser University
simon.spacapan@uni-mb.si

Bojan Mohar
University of Ljubljana
Slovenia
Bojan.Mohar@fmf.uni-lj.si

MS1

Path Spectrum Sets

A path in a graph is maximal if it is not a proper subpath of any other path of the graph. The Path Spectrum of a graph is the set of lengths of all maximal paths in the graph. A set of positive integers is an Absolute Path Spectrum if there are an infinite number of graphs with that Path Spectrum. Known results on the path spectrum will be summarized, some new results on Non-Path Spectrum Sets, and new results on Absolute Path Spectrum Sets will be presented.

Ralph Faudree
University of Memphis
Department of Math Sciences
rfaudree@memphis.edu

MS1

F-Avoiding Hamiltonian Graphs

Let G be a graph and H be a subgraph of G. If G contains a hamiltonian cycle C such that $E(C) \cap E(H)$ is empty, we say that C is an *H-avoiding hamiltonian cycle*. Let F be any graph. If G contains an H-avoiding hamiltonian cycle for every subgraph H of G such that $H \cong F$, then we say that G is *F-avoiding hamiltonian*. In this talk, we give minimum degree and degree-sum conditions which assure that a graph G is F-avoiding hamiltonian for various choices of F. If time permits, we will also undertake a brief discussion of F-avoiding pancyclic graphs.

Michael Ferrara
Dept. of Theoretical and Applied Mathematics
University of Akron
mjf@uakron.edu

MS1

Strong Connectivity and Cycle Structure

In this talk we consider several new developments on strong connectivity questions in graphs. For a fixed multigraph H, possibly containing loops, with $V(H) = \{h_1, \ldots, h_k\}$ we say a graph G is H-linked if for every choice of k vertices $v_1, \ldots, v_k$ in G, there exists a subdivision of H in G such that v_i represents h_i (for all i). Using a k matching as the graph H, we obtain the well-known idea of a k-linked graph. An H-immersion in G is similar to H-linkage, except that the paths in G, playing the role of the edges of H, are only required to be edge disjoint. We determine minimum degree conditions for a graph G to contain an H-linkage. We further generalize these results to find conditions for a graph G to contain an H-immersion with a bounded number of vertex repetitions on any choice of k vertices. We then show applications of this work to cycle questions. This talk spans work in several papers and with several sets of coauthors.

Ronald Gould
Dept. of Mathematics and Computer Science
Emory University
rg@mathcs.emory.edu

MS1

Cycle Lengths Occurring in Hamiltonian Graphs

A simple graph of order n is said to be pancyclic if it contains cycles of all lengths fro 3 to n. We consider hamiltonian graphs with two vertices having "large" degree sum. The degree sum that insures that the graph is pancyclic will be given. We also consider the problem of determining what cycle lengths must be present in the graph when this degree sum condition is reduced. This work generalizes results of Schmeichel and Hakimi.

Michael Jacobson
Dept. of Mathematics
University of Colorado at Denver
Michael.Jacobson@cudenver.edu

MS1

Placing Vertices and Subgraphs on Cycles of Prescribed Lengths

Given a graph G of sufficiently large order, we provide a variety of sharp degree conditions for the existence of cycles with additional properties. In particular, one of our theorems provides sharp degree sum conditions for the existence of vertex disjoint cycles, each of which has a prescribed length and contains a prescribed vertex. This, and similar results, will be presented along with current and future work in this area.

Colton Magnant
Emory University
cmagnan@mathcs.emory.edu

MS2

The First Three Levels of an Order Preserving Hamiltonian Path in the Subset Lattice

A path $\{S_1, \ldots, S_k\}$ in the lattice of subsets of $\{1, \ldots, n\}$ is monotone, if $S_1 = \emptyset$ and for every i, either (a) every subset of S_i appears among the sets $S_1, \ldots, S_{i-1}$, or (b) only one (say S) does not, furthermore $S_{i+1} = S$. It is not known whether there is a monotone Hamiltonian Path in the subset lattice. We show that there exist a monotone path that contains all sets of size at most 3 by providing an explicit construction.

Csaba Biro, David Howard
Georgia Institute of Technology
biro@math.gatech.edu, dmh@math.gatech.edu

MS2

Maximal Antichains in Finite Partially Ordered Sets

An antichain in a (partially) ordered set X is an unordered subset, and a fibre of X intersects every maximal antichain. There are well-known combinatorial problems involving enumeration of antichains, such as Dedekind's problem. More recent questions involve enumeration of maximal antichains and estimates of minimum fibre sizes. We will present results and problems of these types, along with some natural graph and hypergraph analogues.

Dwight Duffus
Emory University
Mathematics and Computer Science Department
dwight@mathcs.emory.edu

MS2

Large Families of Subsets Avoiding a Given Con-

figuration

Translating Turán-type questions to ordered sets, we are interested in the maximum size $\mathrm{La}(n, H)$ of a family of subsets of the set $\{1, 2, \ldots, n\}$, subject to the condition that a certain configuration (subposet H) is excluded. For instance, Sperner's Theorem solves the problem for H being a two-element chain. We survey results of this kind, including bounds when H is the four-element N poset (joint with Gyula O.H. Katona) or a more general height two poset.

Jerrold R. Griggs, Linyuan Lincoln Yu
University of South Carolina
griggs@math.sc.edu, lu@math.sc.edu

MS2

Characterizing Posets with Linear Discrepancy 2

In a linear extension of a poset there exists a maximum distance between any two incomparable elements in the extension. The discrepancy of a poset is defined to be the minimum of these maximums over every linear extension for a poset. A k-discrepancy-irreducible poset is defined to be a poset such that if any element is removed from the poset there exists a linear extension such that the distance between any two incomparable elements is no more than $k - 1$. In this paper we show the family of 3-discrepancy-irreducible posets and classify all posets of discrepancy 2.

David Howard, Mitch Keller, Stephen Young
Georgia Institute of Technology
dmh@math.gatech.edu, keller@math.gatech.edu, young@math.gatech.edu

MS2

Duality for Semiantichains and Unichain Coverings in Products of Special Posets

A *semiantichain* in a product of posets is a family whose members are comparable only if they differ in both coordinates. A *unichain* is a chain that is constant in one coordinate. Saks and West conjectured that for every product of partial orders, the maximum size of a semiantichain equals the minimum number of unichains needed to cover the product. We prove this when both factors have width 2. We also use the characterization of product graphs that are perfect to prove it when both factors have height 2. Finally, we make some observations about the case where both factors have dimension 2.

Qi Liu
Wharton School
University of Pennsylvania
qiliu@wharton.upenn.edu

Douglas B. West
Univ of Illinois - Urbana
Department of Mathematics
west@math.uiuc.edu

MS3

Eigenvalues of 2-Edge Coverings

A 2-edge-covering between G and H is an onto homomorphism from the vertices of G to the vertices of H so that each edge is covered twice and edges in H can be lifted back to edges in G. We show how to compute the spectrum of G by computing the spectrum of two smaller graphs, namely a (modified) form of the covered graph H and another graph which we term the anti-cover. This is done for both the adjacency matrix and the normalized Laplacian. We also give an example of two anti-cover graphs which have the same normalized Laplacian, and give some simple applications.

Steve Butler
UC San Diego
USA
sbutler@math.ucsd.edu

MS3

Matchings and Connectivity From Eigenvalues

I will present some old and new connections between the eigenvalues of a graph and its matching number and connectivity.

Sebastian Cioaba
UC San Diego
scioaba@math.ucsd.edu

MS3

The Integral Trees of Index 3

A tree is called integral if all its adjacency eigenvalues are integers. The main results states that there are exactly eleven integral trees with spectral radius (= index) 3. This result is established by a complete computer search. In the talk we will present the theoretic tools that were used to make the search space small enough.

Willem Haemers
Tilburg University
The Netherlands
haemers@uvt.nl

MS3

Using Eigenvalues of Graphs to Solve Problems in Design Theory

In this talk I will give a number of examples of a problem in design theory that can be rephrased as a question about a graph. For all of these examples bounds on the size of a design can be found from an eigenvalue bound from the appropriate graph. The problems I am particularly interested in are related to the Erdős-Ko-Rado theorem, this theorem gives an upper bound on the size of an intersecting set system and describes exactly which systems meet this bound. There are a surprising number of extensions of this famous theorem where the bound can be found using eigenvalue bounds on an appropriate graph.

Karen Meagher
University of Regina

Saskatchewan, Canada
karen.meagher@uregina.ca

MS4

Even Cycles in Graphs

A seminal result of Whitney characterizes when two graphs have the same set of cycles (where cycles are viewed as sets of edges). Namely, two graphs have the same cycle if and only if one can be obtained from the other by repeatedly rearranging the graph along one- and two-vertex cutsets. We are interested in characterizing when two graphs have the same set of even cycles (a cycle is even if it contains an even number of edges). We can give a Whitney type theorem for the case where the graphs have high connectivity or for the case where they contain a sufficient number of pairwise disjoint odd cycles. This is joint work with Irene Pivotto and Paul Wollan.

Bertrand Guenin, Irene Pivotto
University of Waterloo
bguenin@math.uwaterloo.ca, ipivotto@uwaterloo.ca

Paul Wollan
University of Hamburg
wollan@math.uni-hamburg.de

MS4

An Algorithm for Testing Group-Labeled Minors

We discuss the k-linkage problem in group-labelled graphs. At the time of writing this abstract, we believe that we have an efficient algorithm for solving the problem for any fixed finite abelian group, although we have not rigorously verified all of the details. This is joint work with Jim Geelen, University of Waterloo.

Jim Geelen, Tony Huynh
University of Waterloo
jfgeelen@math.uwaterloo.ca, thuynh@math.uwaterloo.ca

MS4

Duality of Width Parameters

Adapting the method introduced in Graph Minors X, we propose a new proof of the duality between the bramble-number of a graph and its tree-width. The technique simplifies the proof of bramble/tree-width duality since it does not rely on Menger's theorem. One can also derive from it all known dual notions of other classical width-parameters. Finally, it provides a dual for matroid tree-width.

Omid Amini
Max Planck Institut für Informatik
amini@mpi-inf.mpg.de

Frédéric Mazoit
LaBRI
Frederic.Mazoit@labri.fr

Nicolas Nisse
Universidad de Chile
nicolas.nisse@lri.fr

Stéphan Thomassé
University of Montpellier 2 - LIRMM
thomasse@lirmm.fr

MS4

Obstructions For Rank-Width Two

We discuss obstructions for graphs of rank-width 2 in terms of pivot-minors. Previously it was known that those obstructions can have at most $(6^3 - 1)/5 = 43$ vertices. We prove that 43 can be improved to 16. The proof actually develops a chain theorem for 4-prime graphs. 4-prime graphs are prime graphs in which every cut of cut-rank ≤ 2 has one side of at most 2 vertices. This is analogous to Hall's result on a chain theorem for 4-connected matroids.

Sang-Il Oum
KAIST
sangil@kaist.ac.kr

MS5

Delaunay Refinement for Manifold Approximation

Delaunay refinement is a greedy technique for constructing provably good approximations of manifolds of small dimensions. The talk will cover some recent results in surface and volume mesh generation, anisotropic mesh generation and manifold reconstruction. The algorithms rely on the concept of Delaunay triangulation restricted to a manifold and on the related concept of the witness complex introduced by de Silva.

Jean-Daniel Boissonnat
INRIA, France
Jean-Daniel.Boissonnat@sophia.inria.fr

MS5

The Geometric Centre of Unit Disc Graphs

Motivated by the gateway placement problem in wireless networks, we consider the *geometric k-centre* problem on unit disc graphs: given a set of points P in the plane, find a set F of k points in the plane that minimizes the maximum graph distance from any vertex in P to the nearest vertex in F in the unit disc graph of $P \cup F$. We describe efficient polynomial-time solutions to this problem for any fixed k, and consider generalizations on related intersection graphs.

Stephane Durocher, Krishnam Raju Jampani
University of Waterloo
Canada
sdurocher@cs.uwaterloo.ca, krjampan@uwaterloo.ca

Anna Lubiw
University of Waterloo, Canada
alubiw@uwaterloo.ca

Lata Narayanan
Concordia University
Canada
lata@cs.concordia.ca

MS5

Simultaneous Embedding of Planar Graphs

Traditional problems in graph visualization deal with a single graph while simultaneous graph visualization involves multiple related graphs. In the latter case nodes are placed in the same locations in all graphs and the graphs are simultaneously embeddable if crossing-free drawings for each graph can be found. We present polynomial time algorithms for simultaneous embedding of several classes of planar graphs and prove that some classes of graphs cannot be simultaneously embedded.

Stephen Kobourov
Department of Computer Science
University of Arizona
kobourov@cs.arizona.edu

MS5

Multi-Agent Planning and Crowd Simulation: Recent Advances and Challenges

I'll briefly present the geometric algorithms we have developed for real-time multi-agent planning and collision avoidance and crowd simulations, then conclude with discussions on open research challenges for geometric computing in these areas.

Ming C. Lin
University of North Carolina
lin@cs.unc.edu her

MS5

Flow-Based Methods in Manifold Reconstruction

We introduce and survey recent developments in the so-called "flow-based" techniques in manifold reconstruction and related problems. These techniques use the continuous flow map that results from the integration of a generalized gradient of the distance function induced by a sample of a submanifold of a Euclidean space as a tool for designing manifold reconstruction algorithms that can guarantee topological type of their output.

Bardia Sadri
Computer Science Dept.
Duke University
sadri@cs.duke.edu

MS6

Critical Non-Colorings of the 600-Cell Proving Bell's Theorem

In recent years several sets of rays have been discovered in four and more dimensions that provide non-coloring proofs of the Bell-Kochen-Specker (BKS) and Bell nonlocality theorems. This talk will give an introduction to this area of research, casting it as a problem in combinatorial geometry. I will then introduce a set of 60 rays derived from the 600-cell and show how they can be used to give non-coloring proofs of the Bell theorems. The 600-cell is a four-dimensional regular polytope with 120 vertices distributed symmetrically on the surface of a four-dimensional sphere; the vertices come in antipodal pairs, and the 60 distinct directions from the center to the vertices yield the 60 rays used in the Bell proofs. My non-coloring proofs make essential use of the Reyes configurations embedded within the 60 rays (a Reyes configuration is a set of 12 points and 16 lines with the property that four lines pass through any point and three points lie on any line). By a critical non-coloring I mean one that ceases to be viable if even a single ray is deleted from it. The talk will focus mainly on the mathematics of the non-coloring proofs, but some possible applications will also be mentioned.

Padmanabhan Aravind
Department of Physics
Worcester Polytechnic Institute
paravind@wpi.edu

MS6

Title Not Available At Time of Publication

Abstract not available at time of publication.

Alexei Ashikhmin
Fundamental Mathematics Group
Alcatel-Lucent Bell Laboratories
aea@research.bell-labs.com

MS6

Mutually Unbiased Bases and Association Schemes

In this talk, we explore the connection between real mutually unbiased bases and association schemes, focusing on the Q-polynomial case.

William J. Martin
Department of Mathematical Sciences
Worcester Polytechnic Institute
martin@wpi.edu

MS6

On Quantum Algorithms for the Hidden Subgroup Problem

Most exponential speedups in quantum computing are obtained by solving instances of the so-called hidden subgroup problem (HSP). A common feature of the resulting quantum algorithms is to make measurements of quantum mechanical states that encode a secret subgroup of known group. While factoring of integers and the computation of discrete logarithms in abelian groups can be solved efficiently within this framework on a quantum computer, a tantalizing open problem is whether it also lends itself to an efficient quantum algorithm for the graph isomorphism problem. In this talk we address this question by analyzing the approach to graph isomorphism via HSPs in the symmetric group of all permutations. We show that highly entangled measurements on at least Omega(n log n) quantum states are necessary to get useful information, matching an information theoretic upper bound. This is joint work with Sean Hallgren and Pranab Sen.

Martin Roetteler
Quantum IT Group

NEC Laboratories America
mroetteler@nec-labs.com

MS6

Quantum State Tomography and 2-Designs

Optimal measurements for quantum state tomography are characterized by 2-designs. This result is true for several different types of measurements: mutually unbiased bases (Wootters and Fields, 1989; Klappenecker and Roetteler, 2005), general rank-one measurements (Scott, 2006), orthogonal rank-one measurements, and "two-outcome" measurements. In this talk, we explain this connection and describe some new constructions. This talk is based on joint work with Andrew Scott, Martin Roetteler, and Chris Godsil.

Aidan Roy
Quantum Information Science
University of Calgary
aroy@qis.ucalgary.ca

MS7

On Graph Classes and Powers of Graphs

Chordal graphs are among the most important graph classes. They are well known for nice structural properties and various applications. They have many facets such as tree structure, clique separators, perfect elimination orderings, Helly property, convexity, and various other aspects. It is well known that odd powers of chordal graphs are chordal. In this talk we discuss similar properties of various other classes which are closely related to chordal graphs, and we also consider natural variants of powers of graphs.

Andreas Brandstaedt
Universität Rostock
ab@informatik.uni-rostock.de

MS7

A Characterization of b-Perfect Graphs

A b-coloring is a coloring of the vertices of a graph such that each color class contains a vertex that has a neighbor in all other color classes. The b-chromatic number of a graph G is the largest integer k such that G admits a b-coloring with k colors. A graph is b-perfect if the b-chromatic number is equal to the chromatic number for every induced subgraph H of G. A graph is minimally b-imperfect if it is not b-perfect and every proper induced subgraph is b-perfect. We conjecture that a graph is b-perfect if and only if it does not contain a graph from a certain list of 22 graphes as an induced subgraph. We present several partial results on this conjecture. This is joint work with Frédéric Maffray and Meriem Mechebbek.

Chinh Hoang
Wilfrid Laurier University
Dept of Physics and Computing Science
choang@wlu.ca

MS7

On Probe Graph Classes

Abstract not available at time of publication.

Ton Kloks
School of Computing, Faculty of Engineering
University of Leeds, UK
kloks@comp.leeds.ac.uk

MS7

On Graph Classes Determined by Convexity in Graphs

A collection $\mathcal{M}$ of subsets of a finite set V is an alignment of V if $\mathcal{M}$ is closed under intersections and contains both V and the empty set; in that case the elements of $\mathcal{M}$ are convex sets. The convex hull of $S \subseteq V$ is the smallest convex set that contains S. For $X \in \mathcal{M}$ a point $x \in X$ is an extreme point for X if $X \setminus \{x\} \in \mathcal{M}$. An alignment with the additional property that every convex set is the convex hull of its extreme points is a convex geometry. The Steiner interval of a set S of vertices in a connected graph G is the collection of all vertices that belongs to some Steiner tree for S, i.e., a sub-tree of G of smallest size containing S. We characterize graph classes that form the convex geometries of alignments that are defined in terms of Steiner intervals.

Ortrud R. Oellermann
The University of Winnipeg
o.oellermann@uwinnipeg.ca

Morten H. Nielsen
University of Winnipeg
m.nielsen@uwinnipeg.ca

MS7

On Helly Classes of Graphs

In 1923, Eduard Helly published a celebrated theorem, which originated the well known Helly property. Say that a family of subsets has the Helly property when every subfamily of it, formed by pairwise intersecting subsets, contains a common element. There are many generalizations of this property which are relevant to parts of mathematics and computer science, and which motivated the definition of some different classes of graphs and hypergraphs. In this talk, we survey computational aspects of the Helly property. In the context of discussing the recognition of these classes of graphs and hypergraphs, we describe algorithms for solving different problems arising from the basic Helly property, or else present NP-hardness results.

Mitre Dourado
Universidade Federal do Rio de Janeiro
mitre@nce.ufrj.br

Fabio Protti
Instituto de Matemática e NCE
Universidade Federal do Rio de Janeiro
fabiop@nce.ufrj.br

Jayme L. Szwarcfiter
Universidade Federal do Rio de Janeiro

jayme@nce.ufrj.br

MS8

Biplanar Crossing Numbers

The crossing number $cr(G)$ of a graph G is the minimum number of edge crossings with which the graph can be drawn in the plane. The biplanar crossing number of a graph G is the minimum of $cr(G_1)+cr(G_2)$, where G_1 and G_2 are graphs on the same vertex set as G such that the union of their edge set is the edge set of G. We examine how much the crossing number and the biplanar crossing number of a graph can differ. This is joint work with László Székely, Ondrej Sýkora and Imrich Vrťo.

Eva Czabarka
Department of Mathematics
University of South Carolina
czabarka@math.sc.edu

MS8

Hanani-Tutte on the Projective Plane

Hanani (1934), Tutte (1970), and others have given proofs for the following theorem: In any planar drawing of a nonplanar graph, there are two non-adjacent edges that cross an odd number of times. We prove the analogous result for the projective plane: For any drawing on the projective plane of a graph that cannot be embedded on the projective plane, there are two non-adjacent edges that cross an odd number of times.

Michael J. Pelsmajer
Illinois Institute of Technology
Department of Applied Mathematics
pelsmajer@iit.edu

Despina Stasi
Mathematics, Statistics, and Computer Science
University of Ilinois at Chicago
stasi@math.uic.edu

Marcus Schaefer
DePaul University
School of Computing
mschaefer@cti.depaul.edu

MS8

On the Induced Matching Problem

We study extremal questions on induced matchings in several natural graph classes. We argue that these questions should be asked for twinless graphs, that is graphs not containing two vertices with the same neighborhood. We show that planar twinless graphs always contain an induced matching of size at least $n/40$ while there are planar twinless graphs that do not contain an induced matching of size $(n + 10)/27$. We derive similar results for outerplanar graphs and graphs of bounded genus. These extremal results can be applied to the area of parameterized computation. For example, we show that we can decide in time $O(91^k + n)$ whether a planar graph contains an induced matching of size at least k.

Iyad Kanj
DePaul University
ikanj@cti.depaul.edu

Michael J. Pelsmajer
Illinois Institute of Technology
pelsmajer@iit.edu

Marcus Schaefer
DePaul University
School of Computing
mschaefer@cti.depaul.edu

MS8

Open Problems on Crossing Number

The talk will review open problems about crossing numbers, starting with the 50 years old Zarankiewicz Conjecture, and arriving at more recent problems.

Laszlo Szekely
University of South Carolina
szekely@math.sc.edu

MS9

Submodular Approximation: Sampling-based Algorithms and Lower Bounds

We introduce several natural optimization problems using submodular functions and give asymptotically tight or close upper and lower bounds on approximation guarantees achievable using polynomial number of queries to a function-value oracle. The optimization problems we consider are submodular load balancing, submodular sparsest cut, submodular balanced cut, submodular knapsack. We also give a new lower bound for approximately learning a monotone submodular function; and show that much tighter lower bounds will require a different approach.

Lisa Fleischer
Dartmouth College
lkf@cs.dartmouth.edu

MS9

Network Decompositions with Applications to Anomynity

Some anonymity protocols for communication over the internet rely on suitable decompositions of underlying graphs and the several objective functions associated with these protocols relate to well-known graph parameters. We discuss these relations for an anonymity protocol based on cycle-coverings and present some related results.

Dieter Rautenbach
Institut fuer Mathematik
TU Ilmenau
dieter.rautenbach@tu-ilmenau.de

MS9

Robust Optimization of Networks

We consider several models of how to design a cheapest network that supports any traffic specified by a demand matrix $[d_{ij}]$ in a given set, or polytope. We show that the complexity of this problem depends on the choice of polytope, as well as whether we are allowed to adapt our routings in response to changing traffic patterns. We also show some empirical results that show the applicability of these ideas to data networks.

Bruce Shepherd
McGill University
bruce.shepherd@mcgill.ca

MS9

Steiner Trees in Chip Design

Finding shortest Steiner trees in grids and packing Steiner trees subject to various constraints are two major subproblems in chip design. The networks in which we look for Steiner trees are huge, and instances need to be solved fast. We will outline the role of Steiner trees in this application and present new algorithms with surprising performance.

Jens Vygen
University of Bonn
vygen@or.uni-bonn.de

MS10

Graph and Hypergraph Models and Algorithms for Sparse Matrix-Vector Multiplication

Combinatorial models using graphs and hypergraphs are frequently used in scientific computing. We give an overview of models and algorithms for an important kernel, parallel sparse matrix-vector multiplication. This is a surprisingly rich model problem, and relevant for other computations as well. We present recent research in 2D data distribution methods, using both graphs and hypergraphs. We demonstrate these techniques can significantly reduce communication volume compared to standard methods.

Erik G. Boman
Sandia National Labs, NM
Scalable Algorithms Dept.
egboman@sandia.gov

Michael M. Wolf
University of Illinois, Urbana-Champaign
mmwolf@uiuc.edu

MS10

Approximation Algorithms for Vertex Weighted Matching

We describe a 2/3-approximation algorithm for computing maximum vertex-weighted matchings in bipartite graphs. This approximation ratio is better than what has been achieved for the edge-weighted matching problem. Our work leads to new algorithms for computing optimal vertex-weighted matchings. The study of vertex-weighted matchings also unveils the rich combinatorial structure of the problem.

Alex Pothen
Purdue University
Dept of Computer Science
pothen@cs.odu.edu

Florin Dobrian
Columbia University
dobrian@cs.odu.edu

Mahantesh Halappanavar
Old Dominion University
mhalappa@cs.odu.edu

MS10

Graph Sparsification by Effective Resistances

Sparsification is the task of approximating a given graph by a sparse graph. We consider two graphs to be similar if the spectra of their Laplacian matrices are close; this notion of approximation preserves many combinatorial properties, such as the weights of all cuts in a graph, and also has applications in solving certain systems of linear equations quickly. We show that every graph on n vertices can be approximated by a subgraph with $O(n\log n)$ edges and conjecture the existence of sparsifiers with $O(n)$ edges, noting that these would generalize expander graphs, which are constant degree sparsifiers for the complete graph.

Nikhil Srivastava, Daniel Spielman
Yale University
nikhil.srivastava@yale.edu, spielman@cs.yale.edu

MS10

Open Problems in Combinatorial Preconditioning

The talk will describe important open problems in combinatorial preconditioning. In particular, I will describe the problem of constructing combinatorial preconditioners for multi-commodity flow problems. I will describe the relationship of matroid bases to preconditioners, the particular matroid that arises in multi-commodity flow problems, and difficulty of using maximum-weight matroid bases as preconditioners in this case.

Sivan A. Toledo
MIT (on sabbatical from Tel Aviv University)
stoledo@tau.ac.il

MS11

The Edge Crossing Graph

Given a geometric graph $\overline{G}$, the *edge crossing graph* of $\overline{G}$, denoted by $\mathrm{EX} = \mathrm{EX}(\overline{G})$, captures the relation of edges crossing. Specifically, EX is the graph defined by $V(\mathrm{EX}) = E(\overline{G})$ and $E(\mathrm{EX}) = \{ef \in E(\overline{G}) : e \text{ and } f \text{ cross in } \overline{G}\}$. The goal is to relate properties of $\mathrm{EX}(\overline{G})$ with $\chi(G)$. It is open whether given an abstract graph H there exists $\overline{G}$ such that $\mathrm{EX}(\overline{G}) \cong H$. This talk reports partial results on both these issues.

Michael O. Albertson
Smith College
albertson@math.smith.edu

MS11

Planar Decompositions and the Minor Crossing Number of Graphs

The minor crossing number of a graph G is the minimum crossing number of a graph that contains G as a minor. Using planar graph decompositions, we prove that for every graph H there is a constant c, such that every graph G with no H-minor has minor crossing number at most $c|V(G)|$. This result complements an earlier result by Wood and Telle about the ordinary crossing number, which in the same context equals at most $c\Delta(G)^2|V(G)|$, where $\Delta(G)$ denotes the maximum degree of G.

Drago Bokal
Faculty of natural science and mathematics
University of Maribor, Slovenia
drago.bokal@uni-mb.si

Gašper Fijavž
Faculty of computer and information science
University of Ljubljana
gasper.fijavz@fri.uni-lj.si

David R. Wood
Department of applied mathematics
Polytechnic University of Catalonia
david.wood@upc.es

MS11

The Rectilinear Crossing Number of the Complete Graph:Closing in (or are We?)

The problem of determining the rectilinear crossing number of the complete graphs K_n is an open classical problem in discrete geometry. A major breakthrough was achieved in 2003 by two teams of researchers working independently (Abrego and Fernandez-Merchant; and Lovasz, Vesztergombi, Wagner and Welzl), revealing and exploiting the close ties of this problem to other classical problems, such as the number of convex quadrilaterals in a point set, the number of $(\leq k)$–sets in a point set, the number of halving lines, and Sylvester's Four Point Problem. Since then, we have seen a sequence of improvements both from the lower bound and from the upper bound sides of the problem, and nowadays the gap between these bounds is very small. Our aim in this talk is to review the state of the art of these problems.

Gelasio Salazar
Instituto de Fisica
Universidad Autonoma de San Luis Potosi
gsalazar@dec1.ifisica.uaslp.mx

MS12

PTAS for Max. Independent Set on Planar Graphs through Sherali-Adams System

In the eighties a few papers described (different) methods of getting a polytime approximation scheme (PTAS) for certain NP-hard graph problems, most notably vertex-cover and maximum independent set, when the input is planar. All these methods are combinatorial. In this work we show how such PTAS emerge simply from (i) starting with the integer programming for the problems (ii) relaxing them and applying the Sharali-Adams lift and project system. The integrality gaps such relaxations achieve are 1+1/k when the running time is exp(k). Comparing them to the combinatorial algorithms mentioned above, our algorithms have the benefit of robustness. Specifically, even if the graph is not quite planar but close to being one, the integrality gaps are still converging to 1 as above, whereas the combinatorial algorithms don't seem to handle this case well.

Avner Magen, Mohammad Moharrami
University of Toronto
avner@cs.toronto.edu, mohammad@cs.utoronto.edu

MS12

Lift-and-Project Operators for Set Packing and Set Covering Problems on Circulant Matrices

When working with the set packing problem on circulant matrices, widely studied polyhedra appear: the stable set polytope of webs and antiwebs and their clique relaxations. Also, circulant matrices and their blockers have been fairly studied on the set covering problem because they are supposed to be closely connected with mni matrices. In this work, symmetries and asymmetries between set packing and covering problems on circulant matrices are studied through the performance of BCC and N+ operators.

Graciela Nasini
UNR, Argentina
Dept of Math.
nasini@fceia.unr.edu.ar

MS12

Exponential Lower Bounds and Integrality Gaps for Tree-Like Lovasz-Schrijver Procedures

Abstract not available at time of publication.

Toniann Pitassi
University of Toronto
toni@cs.toronto.edu

MS12

Lift-and-Project Methods and the Approximability of Vertex Cover

Lift-and-project methods are used to iteratively tighten linear and semidefinite relaxations by "lifting" the relaxation to a higher dimensional space, adding valid constraints and then projecting back down to the original space. Several recent works study the potential of such methods for designing approximation algorithms. Motivating this work was the realization that the relaxations underlying such breakthrough approximation algorithms like those for Max-Cut (Goemans-Williamson) and Sparsest-Cut (Arora-Rao-Vazirani) are all efficiently derivable using lift-and-project methods. One optimization problem that has attracted attention from approximation algorithms researchers working with lift-and-project methods is the classic Vertex Cover problem. While there exist simple algorithms approximating Vertex Cover within a factor of 2, concerted efforts by many researchers have failed to yield better approximations. The consensus was that semidefinite programming and, in particular, lift-and-project methods were our "last best hope" for obtaining a better approximation for Vertex Cover. We deal a blow against this hope: We show that no polynomial-time semidefinite programming relaxations obtained using the powerful LS+ lift-and-project method of Lovasz and Schrijver can yield better than a 2-o(1) approximation for Vertex Cover.

Iannis Tourlakis, Konstantinos Georgiou, Avner Magen, Toniann Pitassi
University of Toronto
iannis@cs.toronto.edu, konstantinos@cs.toronto.edu, avner@cs.toronto.edu, toni@cs.toronto.edu

MS13

Progress Using the Substitution Method to Bound Critical Probabilities

One of the central problems of percolation theory is determination of critical probability values, p_c, for large classes of percolation models. This is a difficult, and largely unsolved, problem. In this talk we discuss recent progress against this problem using the substitution method. We have adopted new computational methods to make the substitution method tractable over larger regions. These methods include exploitation of symmetry, using network flow algorithms to prove stochastic ordering, and exploitation of non-crossing partitions for certain classes of problems. Using the new computations we greatly improved bounds on p_c for a number of models, but fell short of achieving our challenge goal: disproving Tsallis's conjectured value of p_c for the $(3, 12^2)$ lattice.

William May
Applied Signal Technology
william.d.may@gmail.com

MS13

Approximation Formulas for Percolation Thresholds

The talk will discuss approximation formulas for bond and site percolation thresholds, criteria for evaluating them, and techniques for improving them. Inspired by the bond-to-site transformation, a formula for the average degree of a line graph in terms of the degrees in the original graph is derived and used to improve percolation threshold approximation formulas for two-dimensional lattices.

John Wierman
Dept of Applied Mathematics and Statistics
Johns Hopkins University
wierman@jhu.edu

MS13

An Introduction to Percolation Thresholds

In preparation for the later talks in the mini-symposium, this survey talk will introduce site and bond percolation models and the concept of the critical probability or percolation threshold. Classes of periodic graphs, relationships between them, and previous exact values, estimates, and bounds for their percolation thresholds will be discussed.

John Wierman
Dept of Applied Mathematics and Statistics
Johns Hopkins University
wierman@jhu.edu

MS13

The Triangle-Triangle Transformation and Exact Percolation Thresholds

Abstract not available at time of publication.

Robert Ziff
Dept of Chemical Engineering
University of Michigan
rziff@umich.edu

MS14

Minimum Span Graph Labellings with Separation Conditions

The theory of integer vertex λ-labellings of a graph models the efficient assignment of channels to a network of transmitters. One seeks the minimum span of a labelling such that labels for vertices at distance i are separated by at least a specified amount k_i. We present an overview of the considerable recent progress and future challenges, both on the original case ($k_1 = 2$ and $k_2 = 1$) and on more general models of real-number labellings of infinite graphs.

Jerrold R. Griggs
Univ. of S. Carolina, Columbia
griggs@math.sc.edu

MS14

$L(p, q)$-Labelling of Graphs

An $L(p, q)$-labelling of G is an integer assignment f to the vertex set $V(G)$ such that: $|f(u) - f(v)| \geq p$, if $dist(u, v) = 1$, and $|f(u) - f(v)| \geq q$, if $dist(u, v) = 2$. $\lambda_{p,q}(G)$ is the least integer k such that g has an $L(p, q)$-labelling in $\{1, \dots k\}$. In 1992, Griggs and Yeh conjectured that $\lambda_{2,1}(G) \leq \Delta^2 + 1$, where Δ is the maximum vertex degree in G. We prove this conjecture for sufficiently large Δ. In 1977, Wegner conjectured that $\lambda_{1,1}(G) \leq \left\lfloor \frac{3}{2}\Delta \right\rfloor + 1$ for a planar graph G if $\Delta \geq 8$. We show that $\lambda_{1,1}(G) \leq (1 + o(1)) \frac{3}{2}\Delta$. These two results generalise to $L(p, q)$-labelling and list-colouring.

Frederic Havet
Projet Mascotte, I3S(CNRS/UNSA) and INRIA
fhavet@sophia.inria.fr

Jan Van Den Heuvel

Department of Mathematics
London School of Economics
jan@maths.lse.ac.uk

Colin McDiarmid
University of Oxford, England
cmcd@stats.ox.ac.uk

Bruce Reed
McGill University
breed@cs.mcgill.ca

Jean-Sebastien Sereni
Intitute for nTheoretical Computer Science
Charles University
sereni@kam.mff.cuni.cz

MS14

Ramsey and Survival Games

The (c, s, t)-*Ramsey game* $\mathcal{G}(\rfloor, \int, \sqcup)$ is played by Builder and Painter on a set V of vertices determined by Builder. Starting from the empty graph, Builder constructs an s-uniform hypergraph H by adding edges one by one. When an edge is added, Painter gives it one of c colors. Builder wins if Painter creates a monochromatic copy of K_s^t, the complete s-uniform hypergraph on t vertices. By Ramsey's Theorem, Builder can win by building a large complete hypergraph (with huge chromatic number). We prove for all c, s, t that Builder can win $\mathcal{G}(\rfloor, \int, \sqcup)$ when required to maintain $\chi(H) \leq \chi(K_s^t)$. More strongly, we give a natural definition of coloring number for hypergraphs and show that chromatic number can be replaced by coloring number in this theorem. The proof is based on analysis of the (p, s, t)-*survival game* $\mathcal{S}(\surd, \int, \sqcup)$ played by Presenter and Chooser on a set V of vertices determined by Presenter. The players build an s-uniform hypergraph H. In the ith round Presenter plays a p-subset $P_i \subseteq V$ and chooser selects an s-subset $X_i \subseteq P_i$. The vertices in $P_i - X_i$, and any edges containing them, are removed from H and the edge X_i is added to H. Presenter wins if H ever contains a copy of K_s^t. We prove that Presenter can win $\mathcal{S}(\surd, \int, \sqcup)$ for all c, s, t.

H. A. Kierstead, Goran Konjevod
Arizona State University
kierstead@asu.edu, goran@asu.edu

MS14

Relaxed Colorings of Graphs

A coloring of the vertices of a graph G is called C-relaxed if all monochromatic connected components have order bounded by C. The usual proper coloring is then equivalent to 1-relaxed coloring. We investigate Brooks-type theorems for this relaxed coloring concept and its generalizations, mostly for the case when C is a constant. We discuss both extremal graph theoretic and computational complexity theoretic aspects.

Robert Berke, Tibor Szabo
ETH Zurich, Switzerland
berker@inf.ethz.ch, szabo@inf.ethz.ch

MS14

On-Line Ramsey Theory for Bounded Degree Graphs

The *on-line Ramsey game* is played by Builder and Painter. Builder presents one edge at a time, which Painter must color red or blue. Builder wins if a monochromatic copy of G appears. The *on-line degree Ramsey number* of G is the least k such that Builder can force G without giving degree more than k to any vertex. The value is 3 for paths (with at least four vertices), at most $2\Delta(G)-1$ for trees (which is sharp), and usually 4 for cycles. We also describe general techniques useful for proving upper and lower bounds.

Jane Butterfield, Tracy Grauman, Bill Kinnersley, Kevin Milans, Christopher Stocker
University of Illinois
jbutter2@uiuc.edu, grauman2@uiuc.edu,
wkinner2@uiuc.edu, milans@uiuc.edu,
stocker2@math.uiuc.edu

Douglas B. West
Univ of Illinois - Urbana
Department of Mathematics
west@math.uiuc.edu

MS15

Phylogenetic Analysis of Molecular Interaction Networks

In systems biology, availability of high throughput molecular interaction data provides novel opportunities for modeling and analyzing cellular organization through graph theoretical abstractions. Comparative analysis of these interactions across diverse species indicate that conservation/divergence of networks can be used to understand functional evolution from a systems perspective. In this talk, we discuss the problem of reconstructing phylogenies based on interaction data. For this purpose, we propose a modularity based approach that alleviates intractable graph comparison problems, allow accounting for noise and missing data, and provide insights on the evolution of modularity in biological systems. We show on a comprehensive collection of simulated and real networks that the proposed technique is promising in accurately capturing evolutionary distances between diverse species, is robust to noise, and outperforms existing phylogenetic network analysis methods.

Mehmet Koyuturk
Case Western Reserve University
Depertment of Electrical Engineering and Computer Science
koyuturk@eecs.case.edu

MS15

Identification Characters with Minimal Homoplasy for Inferring Maximum Parsimony Trees

Parsimony methods infer phylogenetic trees by minimizing number of character changes required to explain observed differences. Parsimony methods may however be confused by occurrence of homoplasy - a situation where species share the same properties (characters) but these characters are not derived from a common ancestor. Instead, they are arrived to by two independent evolutionary pathways (e.g. wings in birds and bats). In the presence of excess of homoplasy, parsimony methods often produce incorrect trees. We discuss graph-theoretical and methods of controlling homoplasy in the data. Based on these graph-theoretical insights, we developed procedure for the identification and analysis of conserved characters with minimal homoplasy and show the applicability of our approach to solving hard phylogenetic problems. The results discussed in this talk have been obtained in collaboration with Eugenie Koonin, Igor Rogozin, and Jie Zhang.

Teresa Przytycka
NCBI, NIH
przytyck@ncbi.nlm.nih.gov

MS15

Analyzing Genome Rearrangements in Evolution and Cancer

Mutations in genomes range from single letter changes in the DNA sequence to rearrangements, gains, or losses of large pieces of DNA. In particular, mammalian genomes contain extensive segmental duplications, many of which are complex mosaics of fragments of numerous other segmental duplications. A similar phenomenon has recently been observed in cancer genomes that contain complicated patterns of overlapping rearrangements and duplications. We describe algorithms to determine a parsimonious sequence of rearrangement and duplication operations that transform one genome sequence into another genome sequence. We use these algorithms to analyze segmental duplications in the human genome and genome organization in cancer.

Ben Raphael
Brown University
braphael@cs.brown.edu

MS15

Algorithms for Identifying Potential Targets on Essential Pathways and Protein-Protein Interaction Networks of Pathogens

As pathogens evolve effective schemes to overcome the effect of antibiotics, the prevalent "one drug and one drug target" approach is falling behind. We propose novel strategies for identifying potential multiple-drug targets in pathogenic PPI networks with the goal of disrupting known pathways/complexes. Given a set S of pathogenic pathways/complexes, we first consider computing the minimum number of proteins (with no human orthologs) whose removal from the PPI network disrupts all pathways/complexes. Unfortunately even the best approximation algorithms for this (NP-hard) problem return too many targets to be practical. Thus we focus on computing the optimal tradeoff (i.e. maximum ratio) between the number of disrupted essential pathways/complexes and the protein targets. For this "sparsest cut" problem, we describe two polynomial time algorithms with respective approximation factors of $|S| and O(sqrt(n)) (n : number of nodes)$. On the E.coli PPI network with 9 essential (signaling) paths from the KEGG database, our algorithms show how to disrupt 3 of them by targeting only 3 proteins (2 of them essential proteins). We also consider the case where there are no available essential pathways/complexes to guide us. In order to maximize the number of disrupted "potential" pathways/complexes we show how to compute the smallest set of proteins whose removal partitions the PPI network into two almost-equal sized subnetworks so as to maximize the number of potential pathways/complexes disrupted. This approach yields 28 potential targets (4 of them known drug targets) on the E.coli PPI network whose removal partitions it to two subnetworks with relative sizes of 1 to 5.

Cenk Sahinalp
Simon Fraser University
cenksahinalp@cs.sfu.ca

MS15

Function and Topology in Protein Interaction Networks

In recent years, high-throughput technologies have resulted in large-scale determination of protein-protein interactions for several organisms. Computational analyses of the resulting interaction networks provide new opportunities for revealing cellular organization and uncovering protein function and pathways. In this talk, I will discuss some of my group's recent work on the analysis of protein physical interaction networks, focusing on the interplay between protein function and network structure.

Mona Singh
Princeton University
msingh@cs.princeton.edu

MS16

Small Label Classes in 2-Distinguishing Labelings

A graph G is said to be 2-*distinguishable* if there is a labeling of the vertices with two labels so that only the trivial automorphism preserves the vertex labels. Denote the minimum size of a label class in such a labeling by $\rho(G)$. If we consider labeling the graph by coloring one label class of vertices red and not coloring the other, ρ tells us the minimum number of vertices we need to color to break all symmetry. This talk will introduce ρ and give bounds on $\rho(Q_n)$ and $\rho(K_3^n)$. We will see that both are $\Theta(\log n)$.

Debra L. Boutin
Hamilton College
dboutin@hamilton.edu

MS16

The Distinguishing Chromatic Number (Part II)

Collins and Trenk introduced the distinguishing chromatic number of a graph G, $\chi_D(G)$, as the minimum number of colors needed to color the vertices so that (1) the coloring is a proper graph coloring and (2) the only automorphism of the graph which preserves colors is the identity. Thus $\chi_D(G)$ is closely related to both the chromatic number and the distinguishing number of a graph. A naive approach to finding an upper bound for the distinguishing chromatic number of a graph would be to expect that it would be less than the sum of the distinguishing number plus the chromatic number. In this talk, we provide a tight bound on the distinguishing chromatic number of graphs with abelian automorphism group Γ, where the difference between $\chi_D(G) - \chi(G)$ can be any nonnegative integer, depending on the number of prime power factors of Γ; however, $D(G)$ for graphs with abelian automorphism groups is always less than or equal to 2.

Karen Collins, Mark Hovey
Wesleyan University
kcollins@wesleyan.edu, mhovey@wesleyan.edu

Ann N. Trenk
Wellesley College
atrenk@wellesley.edu

MS16

Distinguishing Number of Line Graphs of Complete Bipartite Graphs

For $s \leq t$ the distinguishing number of the cartesian product of complete graphs of sizes s and t (the line graph of a complete bipartite graphs with part sizes s and t) is either $\lceil (t+1)^{1/s} \rceil$ or $\lceil (t+1)^{1/s} \rceil + 1$. We discuss a proof of this result from the perspective of coloring the edges of a complete bipartite graph and discuss related results.

Garth T. Isaak
Lehigh University
Department of Mathematics
gisaak@lehigh.edu

MS16

The Distinguishing Chromatic Number (Part I)

Albertson and Collins introduced the distinguishing number of a graph as the minimum number of colors needed to color the vertices so that the only automorphism of the graph which preserves colors is the identity. The *distinguishing chromatic number*, $\chi_D(G)$, is defined similarly, except that the coloring must also be proper, that is, adjacent vertices must get different colors. In this talk we discuss results about $\chi_D(G)$ including characterizations of $\chi_D(G)$ for various families of graphs, analogues of Brooks' Theorem, and results that relate $\chi_D(G)$ to the automorphism group of G.

Ann N. Trenk
Wellesley College
atrenk@wellesley.edu

Karen Collins, Mark Hovey
Wesleyan University
kcollins@wesleyan.edu, mhovey@wesleyan.edu

MS16

Genericity of Distinguishing Number Two

In many different situations, the Motion Lemma implies that all but finitely many cases have distinguishing number two, that is having distinguishing number two is generic. Examples are presented from various contexts of groups acting on sets: automorphism of finite groups, automorphims of finite vectors spaces, maps, locally finite (infinite) graphs, general transitive actions.

Thomas Tucker
Colgate University
Ttucker@mail.colgate.edu

MS17

Colorings and Crossings

In a drawing of a graph G, two crossings are dependent if they are incident with a common vertex. A set of crossings is independent if no two are dependent. We conjecture that if G has a drawing whose crossings are all independent, then G has chromatic number at most 5. We prove this when the crossing number is at most 3. We show that if all crossings are independent, then the chromatic number is at most 6. Other connections between crossings and colorings will be examined.

Michael O. Albertson
Smith College
albertson@math.smith.edu

MS17

List Colouring Hypergraphs

We say that a hypergraph H is *L-colourable* for a given assignment $\{L(v) : v \in V(H)\}$ of vertex lists if H has a vertex-colouring c such that $c(v) \in L(v)$ for each v and no edge of H is monochromatic. The hypergraph H is said to be *k-list-colourable* if it is L-colourable for every L satisfying $|L(v)| \geq k$ for each v. We consider a number of problems concerning list colouring of hypergraphs, in particular some that are related to certain transversal problems in hypergraphs.

Penny Haxell
University of Waterloo
pehaxell@math.uwaterloo.ca

MS17

Coloring H-Free Hypergraphs

Let H be an r-uniform hypergraph. What is the minimum number of edges in an H-free r-uniform hypergraph with chromatic number greater than k? We consider this problem for various H. In the special case when H consists of two edges sharing p vertices, we improve the previous best upper bounds due to Kostochka, Rodl, Mubayi and Tetali.

Tom Bohman
Carnegie Mellon University
Department of Mathematics
tbohman@moser.math.cmu.edu

Alan Frieze
Carnegie Mellon University
alan@random.math.cmu.edu

Dhruv Mubayi
University of Illinois-Chicago
mubayi@math.cmu.edu

MS17

Coloring Problems for Graphs That Arise From Posets

There are several challenging graph coloring problems that arise from the study of partially ordered sets. We will present updates on three: the maximum chromatic number of a diagram of an interval order of given height; the performance of first fit coloring on interval graphs; and the chromatic number of arbitrary poset diagrams of bounded height and size.

W. Tom Trotter
Georgia Institute of Technology
trotter@math.gatech.edu

MS17

List Colorings of Planar Graphs

A graph $G = (V, E)$ is k-list colorable if for every list assignment L with $|L(v)| \geq k$ for all $v \in V$ there exists a coloring c of the vertices of G where $c(v) \in L(v)$ for all $v \in V$ and $c(v) \neq c(w)$ for all $vw \in E(G)$. It is well-known that every planar graph is 5-list colorable and there are planar graphs which are not 4-list colorable. Many authors tried to find conditions for planar graphs ensuring k-list colorability for $k \in \{3, 4\}$. The talk gives a recent overview on results in this field.

Margit Voigt
University of Applied Sciences
Dresden
mvoigt@informatik.htw-dresden.de

MS18

Cycles in Pairwise Balanced Designs with Index 1

The *block-intersection* graph of a pairwise balanced design is the graph whose vertices are the blocks of the design and whose edges correspond to the pairs of blocks with non-empty intersection. In this talk, the structure and cycle properties of these graphs will be discussed for designs whose minimum block size is 3 and index is 1. The structure of the more general cases that include those designs with minimum block size 2 or index at least 1 will also be discussed.

Donovan Hare
The University of British Columbia, Okanagan, Canada
donovan.hare@ubc.ca

MS18

Near Ucycles Exist for Subsets

A universal cycle (ucycle) for k-subsets of an n-set X is a cyclic string S of elements from X with the property that every k-subset of X appears exactly once as a contiguous substring of S. Invented by Chung, Diaconis and Graham in the early 1990s, few examples are known to exist. A universal packing (upacking) replaces the "exactly once" condition by "at most once". A near-ucycle is a upacking for which the number of k-subsets that do not appear is asymtotically small compared to $\binom{n}{k}$. Here we prove for all k that near-ucycles exist when n is large enough. This is joint work with Curtis, Hines, and Moyer.

Dawn Curtis, Taylor Hines, Glenn Hurlbert, Tatiana Moyer
Arizona State University
dawn.curtis@asu.edu, taylor.hines@asu.edu, hurlbert@mingus.la.asu.edu, tatiana.moyer@asu.edu

MS18

Hamiltonicity and Restricted Block-Intersection Graphs of T-Designs

Given a combinatorial design $\mathcal{D}$ with block set $\mathcal{B}$, its traditional block-intersection graph $G_{\mathcal{D}}$ is the graph having vertex set $\mathcal{B}$ such that two vertices b_1 and b_2 are adjacent if and only if b_1 and b_2 have non-empty intersection. We consider the S-block-intersection graph, in which two vertices b_1 and b_2 are adjacent if and only if $|b_1 \cap b_2| \in S$. As our main result we prove that $\{1, 2, \ldots, t-1\}$-block-intersection graphs of t-designs with parameters $(v, t+1, \lambda)$ are Hamiltonian whenever $t \geq 3$ and $v \geq t+3$, except possibly when $(v, t) \in \{(8, 5), (7, 4), (7, 3), (6, 3)\}$.

David Pike
Memorial University of Newfoundland
dapike@math.mun.ca

Robert Vandell, Matthew Walsh
Indiana-Purdue University, Fort Wayne
vandellr@ipfw.edu, walshm@ipfw.edu

MS18

Previous and Current Results on Ordering the Blocks of Designs

In 1989, Ron Graham asked if 1-block intersection graphs of Steiner triple systems are Hamiltonian. This is one of the first instances in combinatorics of asking for a particular ordering of the blocks of a design. This Hamiltonicity question has been investigated for BIBDs and PBDs with many parameters. Other research on ordering the blocks of designs include Gray codes and universal cycles of complete hypergraphs, configuration orderings and pair designs. We will introduce the various orderings that have been researched and summarize the results of scientists unable to speak at this symposium. Additionally we will present new results from Megan Dewar's Ph.D. Thesis: rank 3 universal cycles and Gray codes of twofold triples systems, rank 2 universal cycles of cyclic BIBDs, and new configuration orderings including huts and partial parallel classes.

Brett C. Stevens
Carleton University
School of Mathematics and Statistics
brett@math.carleton.ca

Megan E. Dewar
Department of National Defence
megan.dewar@gmail.com

MS18

Single Change Designs

A *single change design* is a block design whose blocks are ordered so that each block can be derived from the preceding one by deleting one member and introducing one new member. We shall discuss single change covering designs and single change BIBDs. There are a number of unsolved problems concerning these classes of designs.

Walter Wallis
Southern Illinois University at Carbondale
USA
wdwallis@math.siu.edu

MS19

Optimal Distribution Networks

We describe a simple geometric argument to explain how material-delivering networks are optimally structured. We outline implications for energy usage in organisms, the structure of plants, transportation systems, and river networks.

Peter Dodds
University of Vermont
pdodds@uvm.edu

MS19

Effects of Community Structure on Respondent Driven Sampling

Abstract: Respondent driven sampling (RDS) is a recently introduced, and now widely used, technique for estimating disease prevalence in hidden populations. The sample is collected through a form of snowball sampling where current sample members recruit future sample members. We present respondent-driven sampling as Markov chain Monte Carlo (MCMC) importance sampling, and examine the effects of community structure and recruitment methodology on the variance of RDS estimates. Past work on RDS has assumed that the variance of RDS estimates is primarily affected by segregation between healthy and infected individuals. We examine an illustrative model to show that this network feature, while important, in isolation tends to significantly underestimate the effects of community structure on RDS estimates. We also show that variance is increased by a sample design feature which allows sample members to recruit multiple future sample members. Our observations are further substantiated by network data collected as part of the National Longitudinal Study of Adolescent Health.

Sharad Goel
Yahoo! Research
goel@yahoo-inc.com

Matthew Salganik
Princeton University
mjs3@princeton.edu

MS19

The Structure and Dynamics of Social Communication Networks

Social networks have attracted great interest in recent years, largely on the account of their relevance to information processing in organizations, distributed search, and diffusion of social influence. Networks evolve in time, driven by the shared activities and affiliations of their members; by similarity of individuals' attributes; and by the closure of short network cycles. I will discuss a study of a dynamic social network comprising students, faculty, and staff at a large university, in which interactions between individuals are inferred from time-stamped e-mail headers recorded over one academic year, and are matched with affiliations and attributes. The results show that in the absence of global perturbations, network-level properties appear stable, whereas individual properties fluctuate, and the network evolution is driven by a combination of effects arising from network topology itself and the organizational structure in which the network is embedded.

Gueorgi Kossinets
Cornell University
gk67@cornell.edu

MS19

Persistent Homology of Leaf Networks

In this talk, I will present our attempt to get a better understanding of various leaf networks by looking at their certain geometric and topological descriptors. Our approach is based on the notion of persistent homology. I shall briefly describe the concept and show how it can be used to capture important information about leaf networks and perhaps lead to a novel method of leaf classification.

Yuriy Mileyko
Georgia Institute of Technology
yury@cs.duke.edu

MS20

Capacitated Domination, Tetrominoes, and Computers

An r-capacitated dominating set of a graph G is a set $\{v_1, \ldots, v_k\}$ of vertices such that there is a partition $(V_1, \ldots, V_k)$ of the vertex set where for all i, $v_i \in V_i$, v_i is adjacent to all of $V_i - \{v_i\}$, and $|V_i| \leq r + 1$. The r-capacitated domination number $\P_r(G)$ is the minimum cardinality of an r-capacitated dominating set. We provide bounds, properties and algorithmic results on $\P_r$. Some of the bounds are produce by an automated computer program. We also show a connection with tetrominoes, which are polyominoes formed from four squares stuck together to form a T. We show that an $n \times n$ square with n odd cannot be tiled with tetrominoes to leave one hole. This includes joint work with James Huff and Steve Hedetniemi.

Wayne Goddard

School of Computing
Clemson University
goddard@clemson.edu

MS20

A New Bound on the Domination Number of Graphs with Minimum Degree Two

For a graph G, let $\gamma(G)$ denotes the domination number of G and let $\delta(G)$ denote the minimum degree among the vertices of G. A vertex x is called a bad-cut-vertex of G if $G - x$ contains a component, C_x, which is an induced 4-cycle and x is adjacent to at least one but at most three vertices on C_x. A cycle C is called a special-cycle if C is a 5-cycle in G such that if u and v are consecutive vertices on C, then at least one of u and v has degree 2 in G. We let $\mathrm{bc}(G)$ denote the number of bad-cut-vertices in G, and $\mathrm{sc}(G)$ the maximum number of vertex disjoint special-cycles in G that contain no bad-cut-vertices. We say that a graph is (C_4, C_5)-free if it has no induced 4-cycle or 5-cycle. Bruce Reed [Paths, stars and the number three. Combin. Probab. Comput. 5 (1996), 277–295] showed that if G is a graph of order n with $\delta(G) \geq 3$, then $\gamma(G) \leq 3n/8$. In this paper, we relax the minimum degree condition from three to two. Let G be a connected graph of order $n \geq 14$ with $\delta(G) \geq 2$. As an application of Reed's result, we show that $\gamma(G) \leq \frac{1}{8}(3n + \mathrm{sc}(G) + \mathrm{bc}(G))$. As a consequence of this result, we have that (i) $\gamma(G) \leq 2n/5$; (ii) if G contains no special-cycle and no bad-cut-vertex, then $\gamma(G) \leq 3n/8$; (iii) if G is (C_4, C_5)-free, then $\gamma(G) \leq 3n/8$; (iv) if G is 2-connected and $d_G(u) + d_G(v) \geq 5$ for every two adjacent vertices u and v, then $\gamma(G) \leq 3n/8$. All bounds are sharp.

Michael A. Henning
University of KwaZulu-Natal
henning@ukzn.ac.za

Ingo Schiermeyer
Technische Universitaet Bergakademie Freiberg
Institut fuer Diskrete Mathematik und Algebra
schierme@math.tu-freiberg.de

Anders Yeo
University of London, United Kingdom
anders@cs.rhul.ac.uk

MS20

Protection of Graphs

In graph protection, guards located at vertices of a graph G defend the vertices against a sequence of attacks. A guard can protect the vertex at which its located and move to a neighbouring vertex to defend an attack there. I shall mainly discuss eternal total domination, in which the sequence of attacks is infinitely long and the configuration of guards induces a total dominating set before and after each attack has been defended.

Kieka Mynhardt
University of Victoria
Victoria, BC, Canada
mynhardt@math.uvic.ca

Chip Klostermeyer
University of North Florida
klostermeyer@hotmail.com

Paul Grobler
Stellenbosch University
South Africa
pjpgrobler@gmail.com

MS20

Random Procedures for Constructing Dominating Sets

Abstract not available at time of publication.

Dieter Rautenbach
Institut fuer Mathematik
TU Ilmenau
dieter.rautenbach@tu-ilmenau.de

MS20

An Upper Bound on the Domination Number of n-Vertex Connected Graphs

Abstract not available at time of publication.

Burak Stodolsky
Department of Mathematics
University of Illinois Urbana Champaign
stodlsky@math.uiuc.edu

MS21

(7,2)-Edge-Choosability of Some 3-Regular Graphs

A graph is $(7,2)$-*edge-choosable* if, for every assignment of lists of size 7 to the edges, it is possible to choose two colors for each edge from its list so that no color is chosen for two incident edges. We show that every 3-edge-colorable graph is $(7,2)$-edge-choosable and also that many non-3-edge-colorable 3-regular graphs are $(7,2)$-edge-choosable.

Daniel W. Cranston
DIMACS Center
dcransto@gmail.com

Douglas B. West
Univ of Illinois - Urbana
Department of Mathematics
west@math.uiuc.edu

MS21

Edge Colouring Cubic Toroidal Maps with Two Odd Faces

We show that every 3-regular toroidal graph with at most two odd faces and facewidth at least two is 3-edge colourable. This partially answers a question of Grunbaum. Along the way, we characterize the family of such graphs having no face of length less than five.

Luis Goddyn
Simon Fraser University, Canada

goddyn@cs.sfu.ca

Maryam Verdian Rizi
Simon Fraser University
mverdian@math.sfu.ca

MS21

Minimum Cost Colourings and Homomorphisms

I will survey recent results on various aspects of list homomorphism and minimum cost homomorphism problems; this will include work with and/or of Rafiey, Gupta, Karimi, Feder, Huang, Gutin, and Yeo. Relations with minimum cost colourings will be briefly mentioned.

Pavol Hell
School of Computer Science
Simon Fraser University
pavol@cs.sfu.ca

MS21

Shortest Cycle Cover Problem for Graphs with Minimum Degree Three

The notion of flows in graphs is dual to that of graph coloring. The Shortest Cycle Cover Conjecture, known to imply the Cycle Double Cover Conjecture (closely related to flows in graphs), asserts that every bridgeless graph G has a cover by cycles with total length at most $7m/5$, where $m = |E(G)|$. The best known general bound is $5m/3$, due to Alon and Tarsi (1985) and to Bermond, Jackson, and Jaeger (1983). For cubic graphs, the best known bound of $44m/27$ is due to Fan (1994). For cubic graphs, we improve the bound to $34m/21$, and we extend the bound of $44m/27$ to graphs with minimum degree 3.

Tomas Kaiser
University of West Bohemia, Pilsen
kaisert@kma.zcu.cz

Daniel Kral
Charles University
kral@kam.mff.cuni.cz

Bernard Lidicky
Charles University, Prague
bernard@kam.mff.cuni.cz

Pavel Nejedly
Department of Applied Mathematics
Charles University, Prague
bim@kam.mff.cuni.cz

Robert Samal
Simon Fraser University, Burnaby
rsamal@sfu.ca

MS21

Cycles in Sparse Graphs

Erdős and Hajnal conjectured that in a graph of infinite chromatic number, the sum of reciprocals of cycle lengths is divergent. We show that if an infinite increasing sequence of even integers grows no faster than towers of two $(2, 2^2, 2^{2^2}, \ldots)$, then every n-vertex graph of average degree at least $\exp(8 \log^* n)$ contains a cycle of length in that sequence. This result is tight, in the sense that there are sequences growing slightly faster than towers of two for which the conclusion is no longer true.

Jacques Verstraete
University of California-San Diego
jverstra@math.ucsd.edu

MS22

There are 1,132,835,421,602,062,347 Nonisomorphic One-Factorizations of K_{14}

We have recently established by means of a computer search that a complete graph on 14 vertices has 98,758,655,816,833,727,741,338,583,040 distinct and 1,132,835,421,602,062,347 nonisomorphic one-factorizations. This talk will give an overview of the techniques used in the search and the consistency checks carried out to gain confidence in the results. A preprint is available at (`http://arxiv.org/abs/0801.0202`).

Petteri Kaski
Helsinki Institute for Information Technology HIIT
CS Dept., University of Helsinki
petteri.kaski@cs.helsinki.fi

Patric Ostergard
Helsinki University of Technology
Dept. of Communications and Networking
patric.ostergard@tkk.fi

MS22

On the Football Pool Problem

The Football Pool Problem amounts to determine the smallest covering code of radius d of ternary words of length v. For $d = 1$ and $v = 6$, the optimal code size z_6 is only known to satisfy $65 \leq z_6 \leq 73$. Using integer programming techniques, isomorphism pruning and grid computing (built using `Condor` and the grid-computing toolkit), we were able to show that $z_6 \geq 71$ using over 140 CPU years delivered in roughly 92 days.

Jeff Linderoth
Dept. of Industrial and Sys. Eng.
University of Wisconsin, Madison
linderoth@wisc.edu

Francois Margot
Carnegie Mellon University
Tepper School of Business
fmargot@andrew.cmu.edu

Greg Thain
Computer Sciences Dept.
University of Wisconsin, Madison
gthain@cs.wisc.edu

MS22

Covering Arrays Avoiding Forbidden Configurations

Covering arrays are combinatorial designs that are used for testing systems such as software, circuits and networks, where failures can be caused by the interaction between their component/parameter values. In this talk, we consider designing covering arrays when certain pairs of parameter values are prohibited from our test suites (e.g. invalid input combinations, explosive substance combinations). We show that the problem is NP-complete for general alphabet size g, while for $g = 2$, we characterize feasible instances and discuss efficient algorithms.

Peter Danziger
Ryerson University
danziger@ryerson.ca

Eric Mendelsohn
University of Toronto
Department of Mathematics
mendelso@math.utoronto.ca

Lucia Moura
University of Ottawa
Information Technology
lucia@site.uottawa.ca

Brett C. Stevens
Carleton University
School of Mathematics and Statistics
brett@math.carleton.ca

MS22

Transversals in Squares

Define $L(m, n)$ to be the greatest integer such that if each symbol in an $m \times n$ array appears at most $L(m, n)$ times, then the array must have a transversal. There are a few results on $L(m, n)$ and almost nothing is known about the square case. We here devise algorithms for the square case and investigate extremal squares. The results apply to Latin squares, frequency squares, one factorizations of the complete graph and the football pool problem.

John van Rees
University of Manitoba
vanrees@cs.umanitoba.ca

MS23

Graph Theoretic Methods for Identifying Redundancy in Protein-Protein Interaction Networks

We show how a simple "folk" theorem in graph theory (probably due to Erdös) can help us identify simple subgraphs that correspond to possible examples of redundancy in the protein-protein interaction network in yeast. This is joint work with Arthur Brady, Kyle Maxwell, and Noah Daniels.

Lenore Cowen
Dept. of Computer Science
Tufts University
cowen@cs.tufts.edu

MS23

Combinatorics of RNA Secondary Structures

Under a suitable abstraction, complex biological problems can reveal surprising mathematical structure. Modeling RNA folding by plane trees, we prove combinatorial theorems yielding insight into the structure and function of large RNA molecules. We also, with an appropriate local move, obtain a graph of RNA configurations which is isomorphic to the lattice of noncrossing partitions. Thus, the interaction between discrete mathematics and molecular biology motivates new combinatorial theorems as well as advancing biological applications.

Christine E. Heitsch
School of Mathematics
Georgia Tech
heitsch@math.gatech.edu

MS23

Using Integer Linear Programming for Genome-Scale Phylogenetics

Phylogenetics (evolutionary tree inference) is an old problem that has found new importance in the genomic era. We use integer linear programming to solve a multi-commodity flow formulation of binary maximum parsimony Steiner tree inference, a variant particularly relevant to analyzing genetic variations between individuals in a species. This approach let us construct local phylogenies spanning the human genome, which we are using to make inferences about human history and the evolution of our genome.

Russell Schwartz
Biological Sciences and Computer Science Departments
Carnegie Mellon University
russells@andrew.cmu.edu

Srinath Sridhar
Computer Science Department
Carnegie Mellon University
srinath@cs.cmu.edu

Fumei Lam
Computer Science Department
Brown University
lam@cs.brown.edu

Guy Blelloch
Computer Science Department
Carnegie Mellon University
guyb@cs.cmu.edu

R. Ravi
Tepper School of Business
CMU
ravi@cmu.edu

MS23

Distribution of Segment Lengths in Genome Rear-

rangements

In 1938, Dobzhansky and Sturtevant introduced the study of gene orders for constructing phylogenetic trees. We use combinatorial methods (permutations, generating functions, asymptotics, recursions, and enumeration formulas) to study the distributions of the number and lengths of conserved segments of genes between unichromosomal genomes. - Hide quoted text - This generalizes classical work on permutations from the 1940s-60s by Wolfowitz, Kaplansky, Riordan, Abramson, and Moser, who studied decompositions of permutations into strips of ascending or descending consecutive numbers.

Glenn Tesler
University of California, San Diego
gptesler@ucsd.edu

MS23

Graph Algorithms for Protein Structure Prediction and Analysis

Graph-based computational models are a powerful, flexible and efficient way of modeling many biological systems. This talk presents a couple of graph models for protein structure prediction and analysis. In these models, a vertex corresponds to a residue and an edge indicates interaction/spatial proximity relationships between two residues in a protein. Using these models, we can develop algorithms for the solutions of several challenging structure bioinformatics problems by exploring the special properties of these graphs. These algorithms have time complexity dependent on the treewidth of a protein graph model, which is typically small for many protein structure related computational problems.

Jinbo Xu
Toyota Technological Institute at Chicago
j3xu@tti-c.org

MS24

Phase Transition in Random Graphs with Degree Constraints

In this talk we discuss evolution and phase transition in random graphs with degree constraints. Of particular interest are random graphs with a given degree sequence.

Mihyun Kang
Humbollt University (Berlin)
kang@informatik.hu-berlin.de

MS24

Avoiding Small Subgraphs in Achlioptas Processes

Consider the following generalization of the classical random graph process, known as the Achlioptas process. At each round, instead of receiving a single random edge, one receives two random edges and chooses one of them in a deterministic, online fashion. We study the problem of avoiding a fixed subgraph in this context, and determine thresholds for the avoidance of all cycles, cliques, and complete bipartite graphs $K_{t,t}$.

Po-Shen Loh
Department of Mathematics
Princeton University
ploh@princeton.edu

Michael Krivelevich
Dept. of Mathematics
Tel Aviv University
krivelev@post.tau.ac.il

Benny Sudakov
Department of Mathematics
UCLA
bsudakov@math.ucla.edu

MS24

The Second Largest Component in the Supercritical 2D Hamming Graph

The 2-dimensional Hamming graph $H(2, n)$ consists of the n^2 vertices (i, j), $1 \leq i, j \leq n$, two vertices being adjacent when they share a common coordinate. We examine random subgraphs of $H(2, n)$ in percolation with edge probability p, so that the average degree $2(n-1)p = 1 + \epsilon$. Previous work of van der Hofstad and Luczak had shown that in the barely supercritical region $n^{-2/3} \ln^{1/3} n \ll \epsilon \ll 1$ the largest component has size $\sim 2\epsilon n$. Here we show that the second largest component has size close to ϵ^{-2}, so that the dominant component has emerged. This is joint work with Joel Spencer.

Malwina Luczak
LSE (London)
m.j.luczak@lse.ac.uk

MS24

Properties of Random Graphs via Boltzmann Samplers

Abstract not available at time of publication.

Konstantinos Panagiotou
Departement of Computer Science
ETH Zurich
panagiok@inf.ethz.ch

MS24

The Erdos Renyi Phase Transition

The Erdos-Renyi Phase transition is very well studied. The random graph G(n,p) has a phase transition when pt is near one. In this semi-expository talk we describe how the transition occurs and the appropriate mean field scaling so that we can see the transition close up.

Joel Spencer
Department of Mathematics, Courant Institute
New York University, New York, NY 10012, U.S.A.
spencer@cs.nyu.edu

MS25

Cryptography on Real Hyperelliptic Curves

An alternative to the traditional "imaginary" model of a hyperelliptic curve is the less familiar "real" model. Unfortunately, the real model renders arithmetic in the Jacobian via reduced divisors less efficient. However, this model exhibits another "almost-group" structure, termed infrastructure, which in addition to divisor composition supports a second, much faster operation. This talk discusses the real model of a hyperelliptic curve, its two-fold baby step giant step divisor arithmetic, and potential cryptographic applications.

Renate Scheidler
University of Calgary
rscheidl@math.ucalgary.ca

MS25

Complex Double Bases Applied to Scalar Multiplication on Algebraic Curves

In elliptic curve cryptography, the costliest operation is the computation of nP = P + ... + P, called scalar multiplication. It is acknowledged that the existence of fast endomorphisms (such as the Frobenius on Koblitz curves) results in clear performance speedup. I will expose how the use of double base expansions of n gives way to a new class of scalar multiplication algorithms capable of beating the fastest known implementations on Koblitz curves, with negligible additional memory.

Francesco Sica
Mathematics & Computer Science
Mount Allison University
fsica@mta.ca

MS25

Non-Abelian Constructions in Cryptography: Challenges and Hopes

A number of attempts have been made to base secure cryptographic schemes on computational problems in non-abelian algebraic structures. Proposals made range from hash functions and public key encryption schemes to key establishment protocols. Especially constructions using non-abelian groups received a lot of attention. Repeated cryptanalytic successes decreased the initial optimism significantly, however. With a focus on key establishment and hash functions, the talk surveys several non-abelian proposals that have been made in the last years and discusses their security.

Rainer Steinwandt
Florida Atlantic University
rsteinwa@fau.edu

MS25

Bounds for Generalized Separating Hash Families

Perfect hash families and separating hash families are combinatorial structures that have numerous applications in cryptography. In this talk, we look at generalized separating hash families and discuss some recent bounds (necessary conditions for existence) that have been proven. The proof techniques are fairly elementary, and combinatorial in nature. The resulting bounds are quite close to the existence results that can be obtained by application of the probabilistic method.

Douglas R. Stinson
University of Waterloo
David R. Cheriton School of Computer Science
dstinson@uwaterloo.ca

MS25

A Fundamental Cryptographic (?) Algorithm

Cryptosystems which rely for their security on the presumed difficulty of solving the discrete logarithm problem in quadratic number fields execute somewhat more slowly than the standard Diffie-Hellman or RSA techniques. Although this gap has narrowed somewhat in the last several years, in order to narrow it further, there is still a fundamental problem that must be addressed. In this talk, I will describe the most recent progress on this problem.

Hugh Williams
Department of Mathematics & Statistics
University of Calgary
williams@math.ucalgary.ca

MS26

Ranking Groups by Their Actions

We consider ways to extend the definition of the indegree and outdegree of a vertex to a set of vertices in an edge-weighted directed graph. This measure serves as a model for ranking groups based on how they act on or interact with others. The measure itself and related statistics including its mean and variance can be computed quickly and hence can be used for a variety of applications that require either scalability or real-time, interactive data analysis. We pay special attention to applications to biology, market basket analysis, and criminal network analysis. Keywords: indegree, outdegree, edge weights, directed graph, data analysis

Nathaniel Dean
Texas State University, San Marcos
nd17@txstate.edu

Kiran Chilakamarri
Texas Southern University
kchilakamarri@yahoo.com

MS26

Digraph Irregularity Strength

It is an elementary exercise to show that any non-trivial simple graph has two vertices with the same degree. This is not the case for digraphs and multigraphs. We consider generating irregular digraphs from arbitrary digraphs by adding multiple arcs. To this end, we define an irregular labeling of a digraph D to be an arc labeling of the digraph such that the ordered pairs of the sums of the in-labels and out-labels at each vertex are all distinct. We define the strength $\vec{s}(D)$ of D to be the smallest of the maximum labels used across all irregular labelings. A similar definition for graphs has been studied extensively In this talk, we give a general lower bound on $\vec{s}(D)$ and determine $\vec{s}(D)$ exactly for tournaments, directed paths and cycles and the orientation of the path where all vertices have either in-degree 0 or out-degree 0. We also determine the irregularity strength of a union of directed cycles and a union of directed paths, the latter which requires a new result pertaining to finding circuits of given lengths containing prescribed vertices in the complete symmetric digraph with loops. Keywords: Digraph, Irregularity Strength, Irregular Labeling.

Michael Ferrara
Dept. of Theoretical and Applied Mathematics
University of Akron
mjf@uakron.edu

Jesse Gilbert, Mike Jacobson
The University of Colorado, Denver
jesse.gilbert@email.cudenver.edu,
michael.jacobson@cudenver.edu

MS26

An Extension of Strongly Regular Graphs

The Friendship theorem states that if any two people in a party have exactly one common friend, then there exists a politician who is everybodys friend. In this talk we generalize the Friendship theorem. Let λ be any non-negative integer and μ be any positive integer. Suppose each pair of friends has exactly λ common friends, and each pair of strangers have exactly μ common friends in a party. (The corresponding graph is a generalization of strongly regular graphs by relaxing the regularity property on vertex degrees.) We prove that either everyone has exact the same number of friends or there exists a politician who is everybodys friend. Key Words: strongly regular graphs, open neighborhoods

Ralucca M. Gera
Naval Postgraduate School
rgera@nps.edu

Jian Shen
Texas State University, San Marcos
email: js48@txstate.edu

MS26

Computer Methods for Finding Graph Decompositions

Integer programming is a powerful technique for modeling and solving combinatorial search problems. However, the common methods of solving integer programs fare poorly when there is a large amount of symmetry present. We will discuss the use of canonical labellings to reduce the search space for the particular application of finding regular graph decompositions.

Stephen G. Hartke
University of NebraskaLincoln
shartke2@math.unl.edu

MS26

The Rainbow Connectivity of Regular Graphs

A path P in an edge-colored graph (not necessarily a proper edge-coloring) is a rainbow path if no two edges are assigned the same color. For a connected graph G with connectivity $\kappa(G)$ and an integer k with $1 \leq k \leq \kappa(G)$, the rainbow k-connectivity $\mathrm{rc_k(G)}$ of G is the minimum number of colors needed in an edge-coloring of G such that every two distinct vertices u and v of G are connected by at least k internally disjoint u - v rainbow paths. We present some results and open questions in this area of research.

Futaba Okamoto
University of Wisconsin - La Crosse
okamoto.futa@uwlax.edu

PP0

Greed Is Good, But Branching Is Better: A Local-Ratio Style Improvement for Hitting Set of Bundles

In this work, we extend the approximation analysis of the Hitting Set of Bundles (HSB) problem using a greedy, rather than LP-based approach. Using this combinatorial framework, we derive a theorem regarding the structure of the worst-case instances of HSB that leads us to a simple branching improvement scheme. We prove that this branching approach yields the best approximation ratio on an important class of HSB problems, and present experimental results for more general instances.

Kevin M. Byrnes, Alan Goldman
Department of Applied Mathematics
Johns Hopkins University
byrnes@ams.jhu.edu, goldman@ams.jhu.edu

PP0

A Tighter Linear Programming Relaxation of Disjoint Combinatorial Rectangle Cover and Analysis of Its Solution Space

Disjoint combinatorial rectangle cover is an important problem because it presents a lower bound on communication complexity. It can be written in the form of integer programming problem. Karchmer, Kushilevitz and Nisan showed a technique to prove a lower bound on this integer programming problem by LP relaxation. To advance this technique we proposed a tighter LP relaxation of disjoint combinatorial rectangle cover problem and analyzed its solution space using spectral graph theory.

Norie Fu, Kenya Ueno
The University of Tokyo
f_norie@is.s.u-tokyo.ac.jp, kenya@is.s.u-tokyo.ac.jp

PP0

The Partition-Regularity of Pythagorean Triples

The problem at the heart of this research involves understanding the partition-regularity of Pythagorean triples. If one colors the natural numbers with k-colors, must there be a monochromatic solution to the equation $a^2 + b^2 = c^2$? Our approach to the problem is two-fold, including mathematical analysis of the Pythagorean triples as well as creating software to generate bounds for different coloring schemes.

Christopher Poirel
University of South Carolina
chris.poirel@gmail.com

Joshua Cooper
University of South Carolina
Department of Mathemeatics
cooper@math.sc.edu