Program and Schedule

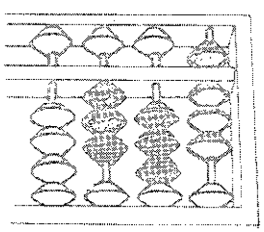
Eighteenth Southeastern International Conference on

COMBINATORICS • GRAPH THEORY • COMPUTING

February 23–27, 1987
University Center
Florida Atlantic University
Boca Raton, Florida

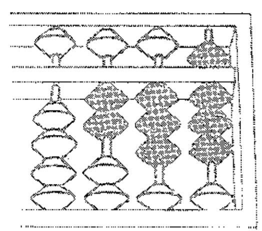
Sponsored by:

•The Department of Mathematics •The Division of Continuing Education
•The Institute for Computer Science and Engineering
•U.S. Office of Naval Research •Project Ocreae (NSA)



Florida Atlantic University
A MEMBER OF THE STATE UNIVERSITY SYSTEM

$$\frac{1}{n}\sum_{d|(b_1\ldots b_r)} \varphi(d)\frac{\left(\frac{n}{d}\right)!}{\left(\frac{b_1}{d}\right)!\cdots\left(\frac{b_r}{d}\right)!}$$



MONDAY

8:00 REGISTRATION (UNIVERSITY CENTER LOBBY)

9:00 WELCOME (GOLD COAST ROOM)

9:20 PLESS "CYCLIC CODES" (GOLD COAST ROOM)

10:20 COFFEE-BOOK EXHIBITS (GOLD COAST ROOM SOUTH)

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
10:40	1 DINITZ	2 WEIDA	3 D.BROWN	4 BARKAUSKAS
11:00	5 E T H WANG	6 STUECKLE	7 MONMA	8 MYRVOLD
11:20	9 RODGER	10 BALAS	11 BLAHA	12 REISCHER
11:40	13 BRICKELL	14 D F HSU	15 WATANABE	16 BAIK

12:00 LUNCH

1:30 PLESS "CYCLIC CODES" (GOLD COAST ROOM)

2:30 COFFEE-BOOK EXHIBITS (GOLD COAST ROOM SOUTH)

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
3:00	17 WERTHEIMER	18 HOST	19 EL-MALLAH	20 MCKEE
3:20	21 SEBERRY	22 CHANDRASEKHARAN	23 NEL	24 STEWART
3:40	25 HARTSFIELD	26 FOWLER	27 FARLEY	28 PALKA
4:00	29 MORENO	30 GRIMALDI	31 EDWARDS	32 BOLAND
4:20	33 RYAN	34 ROWLEY	35 LIPMAN	36 CHINN
4:40	37 RUSHANAN	38 SCHUSTER	39 SIEGRIST	40 GARGANO
5:00	41 SIMMONS	42 BAGGA	43 AMIN	44 WALLER

5:35 TRANSPORTATION to motels (returning about 6:15)

6:00 RECEPTION (RATHSKELLER)

8:00 TRANSPORTATION back to motels

TUESDAY

REGISTRATION BEGINS AT 8:15 IN SECOND FLOOR LOBBY

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
8:35	45 BATTEN	46 BAILEY	47 CUMMINGS	48RADZISZOWSKI
8:55	49 CHEROWITZO	50 NOLIN	51 OPATRNY	52 GLOVER

9:20 MCELEICE "TRELLIS CODES" (GOLD COAST ROOM)

10:20 COFFEE

10:40	53 HARMS	54 CHAO	55 READ	56 FELLOWS
11:00	57 BENNETT	58 NIEDERHAUSEN	59 GOLDBERG	60 RICHTER
11:20	61 KRAMER	62 DE LAURENTIS	63 W-L HSU	64 HEAD
11:40	65 MILLS	66 WALSH	67 HUDSON	68 ENTRINGER

12:00 LUNCH

1:30 MCELEICE "NEURAL NETWORKS" (GOLD COAST ROOM)

2:40 CONFERENCE PHOTO (OUTDOOR STAGE)

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
3:00	69 LUEDEMAN	70 QUINTANA	71 ANDERSON	72 SCHWENK
3:20	73 GUAN	74 DEJTER	75 BRUALDI	76 LIU
3:40	77 MUDER	78 SMYTHE	79 WACHS	80 DUTTON
4:00	81 MULLIN	82 PAULRAJA	83 PIAZZA	84 HARTNELL
4:20	85 MAYS	86 BAREFOOT	87 L CHENG	88 DOMKE
4:40	89 LEONARD	90 ALBERTSON	91 KOTIN	92 CHARTRAND
5:00	93 BHATTACHARYA	94 CATLIN	95 KAHN	96 SCHELP
5:20	97 WALLIS	98 POKRASS	99 MESNER	100 PRITIKIN

5:50 TRANSPORTATION to motels and party
There will be transportation from the motels to the party about 6:25.

6:00 PARTY at Freeman's, 741 Azalea St.
There will be transportation back to the motels from the party.

WEDNESDAY

REGISTRATION BEGINS AT 8:15 IN SECOND FLOOR LOBBY

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
8:35	101 MCFARLAND	102 DAHLHAUS	103 RINGEISEN	104 ALTMAN
8:55	105 FU	106 T.SPENCER	107 LESNIAK	108 LEISS

9:20 ASSMUS "PLANES AND BIPLANES" (GOLD COAST ROOM)

10:20 COFFEE

10:40	109 KEY	110 LEUZE	111 PIPPERT	112 W HARE
11:00	113 TAYLOR	114 SINGH	115 OELLERMANN	116 GALLIAN
11:20	117 PARKER	118 FULLER	119 HEMMINGER	120 DAHBURA

11:50 ASSMUS "PLANES AND BIPLANES" (GOLD COAST ROOM)

12:50 LUNCH

	FAU-ROOM-A	FAU-ROOM-C	ROOM 109	ROOM 113
2:20	Software Session	122 ATKINSON	123 LEWINTER	124 FUREDI
2:40	125 Ealy(2:30)	126 LASKAR	127 WAGNER	128 DEAN
3:00	129 Abello	130 ST HEDETNIEMI	131 TOLMAN	132 LONC
3:20	133 Boyd(3:30)	134 WIMER	135 GRIGGS	136 TRUSZCZYNSKI
3:40		138 CIKANEK	139 ROELANTS	140 HEINRICH
4:00	137 Stinson			
4:20	141 Jaromczyk	142 MAKKI	143 RUSKEY	144 GYARFAS
4:40	(4:30)	146 MONMA	147 GIMBEL	148 HILTON
5:00	149 Fajtlowicz	150 SPINARD	151 HO	152 ELINGHAM

5:35 TRANSPORTATION to motels (returning aboout 6:15)

6:00 CASH BAR (LOUNGE OUTSIDE FAU ROOMS)

7:00 CONFERENCE BANQUET (GOLD COAST ROOM)

There will be transportation back to the motels after the banquet.

REGISTRATION BEGINS AT 8:15 IN SECOND FLOOR LOBBY

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
8:35	153 DE CAEN	154 E HARE	155 IHRIG	156 HONG
8:55	157 MAYBEE	158 K BERMAN	159 MAGLIVERAS	160 VARMA
9:15	161 MCMILLAN	162 HEMMETER	163 EVANS	164 VESTERGARD

9:30 ERDOS "NEW INTEREST IN OLD PROBLEMS"(GOLD COAST ROOM)

10:30 COFFEE

10:50 CHUNG "DIAMETERS OF GRAPHS"(GOLD COAST ROOM)

11:50 LUNCH

1:20 CHUNG "DIAMETERS OF GRAPHS"(GOLD COAST ROOM)
2:20 COFFEE

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
2:40	165 JONES	166 DOW	167 BRAND	168 DI PAOLA
3:00	169 CABLE	170 HADLOCK	171 LEHEL	172 KITTO
3:20	173 LUNDGREN	174 FERNANDEZ	175 MCMORRIS	176 N MANICKAM
3:40	177 HEFNER	178 BOYD	179 RAYCHAUDHURI	180 EALY
4:00	181 EXOO	182 LAPORTE	183 CORNEIL	184 PAYNE
4:20	185 RALL	186 BRIDGLAND	187 EGGLETON	188 deRESMINI
4:40	189 DEO	190 NTAFOS	191 JOHNSON	192 BAKER
5:00	193 HILGERS	194 DAY	195 REGENER	196 KREHER
5:20	197 FAUDREE	198 ROSENFELD	199 S.MANICKAM	200 S-M LEE

5:50 TRANSPORTATION to motels

There will be transportation from the motels to the party some time between 6:20 and 6:40.

6:10 TRANSPORTATION to party

6:00 PARTY at Hoffman's, 4307 N.W. Fifth Ave.

There will be transportation back to the motels from the party.

FRIDAY

REGISTRATION BEGINS AT 8:15 IN SECOND FLOOR LOBBY

	GOLD COAST ROOM	FAU-ROOM-A	FAU-ROOM-C	ROOM 109
8:35	201 Y CHENG	202 TJ REID	203 HOBBS	204 MILLER
8:55	205 RINALDI	206 SIMION	207 BASTANI	208 ABRHAM
9:20	ROBERTS "APPLICATIONS OF GRAPH THEORY" (GOLD COAST ROOM)			
10:20	COFFEE			
10:40	209 V WEI	210 AGNEW	211 GYORI	212 KUANG
11:00	213 Z WANG	214 SMITH	215 PROSKUROSKI	216 I WEI
11:20	217 TOLEDO	218 MEYEROWITZ	219 FISK	220 S WANG
11:50	ROBERTS "APPLICATIONS OF GRAPH THEORY" (GOLD COAST ROOM)			

SEE

YOU

NEXT

YEAR!!!

THIS SCHEDULE IS ACCURATE AS OF FEBRUARY 19, 1987.

SOCIAL EVENTS:

MONDAY FEBRUARY 23: Conference Reception from 6:00 to 7:45 in the Rathskeller. Drink tickets are available to all regular participants (for accounting purposes only; extra tickets may be requested at the reception.)

TUESDAY FEBRUARY 24: The annual Conference Beer Party from 6:00 PM, at the home of Jack and Dille Freeman, 741 Azalea Street (but park on Aurelia),about a one-mile walk from the University.

WEDNESDAY FEBRUARY 25: The Conference Banquet will be held in the Gold Coast Room, with seating at 7:00. A cash bar will be available in the Lounge outside the FAU Rooms from 6:00 to 7:00.

THURSDAY FEBRUARY 26: There will be a party at the home of Fred and Elisabeth Hoffman, 4307 NW 5th Avenue, from 6:00 to 8:00+. It is a walk of less than two miles from the University to the Hoffman home.

MISCELLANEOUS INFORMATION

Registration will be in the first floor lobby of the University Center on Monday, and on the second floor, outside the Gold Coast Room, thereafter.

To leave important messages, phone 393-3078. There will be a bulletin board in the South half of the Gold Coast Room.

There is a coin-operated Xerox machine on the first floor of the University Center.

The Copy Center (behind the police station, which is near the south end of the covered walkway) can xerox onto transparencies. Blank transparencies are available at the bookstore and at the copy center.

The Gold Coast Room and the Florida Atlantic Rooms (FAU Room A-B and FAU Room C) are on the second floor of the University Center. The FAU Rooms are accessible from the lounge area.

COFFEE will be available in the South half of the Gold Coast Room beginning Monday morning, as will an exhibit of books from several publishers, which are there to be examined by participants, and then <u>returned to us for further Conference use</u>. The book exhibits will end at 4:30 Thursday.

TRANSPORTATION: We shall provide van transportation from Day's Inn and the University Inn to the Universaity Center at 8:00 AM, Monday through Friday, making two trips if necessary. There will be van transportation to the motels from the University Center at about 5:35 Monday and Wednesday, 5:50 Tuesday and Thursday, and at about 1:20 on Friday. Van transportation to and from social events will be approximately as in this schedule. Although we attempt to provide all needed transportation, we encourage car-pooling whenever possible.

INVITED LECTURES

ALL OF THE INVITED LECTURES WILL BE HELD IN THE GOLD COAST ROOM.

MONDAY, FEBRUARY 23, Professor VERA PLESS will speak at 9:20 AM and 1:30 PM, on "Duadic Codes Revisited - A New Approach to Cyclic Codes."

TUESDAY, FEBRUARY 24, Professor ROBERT McELEICE will speak at 9:20 AM, on "A New Approach to Trellis Codes," and at 1:30 PM, on "The Capacity of Neural Networks."

WEDNESDAY, FEBRUARY 25, Professor EDWARD ASSMUS will speak at 9:20 AM and 11:50 AM, on "Planes and Biplanes."

THURSDAY, FEBRUARY 26, Professor PAUL ERDOS will speak at 9:30 AM, on "New Interest in Old Problems."

THURSDAY, FEBRUARY 26, Dr. FAN R. K. CHUNG will speak at 10:30 AM and 1:20 PM, on "Diameters of Graphs: Old Problems and New Results."

FRIDAY, FEBRUARY 27, Professor FRED S. ROBERTS will speak at 9:20 AM and 11:50 PM, on "Applications of Graph Theory."

Duadic Codes Revisited - A New Approach to Cyclic Codes
Vera Pless - University of Illinois at Chicago

A new, infinite family of cyclic codes over GF(q), called duadic codes are defined by their idempotent generators. These include all quadratic residue codes of prime length and other interesting algebraic codes. The idempotents of duadic codes over fields of characteristic 2 can be easily constructed. For any GF(q), their existence is easy to determine. Any self-orthogonal $(n,\frac{n-1}{2})$ code is duadic. Any extended cyclic, self-dual code is extended duadic. When extended duadic codes are not self-dual, their duals can be identified. A square-root bound is given for vectors of odd-like weight.

Duadic codes have many connections with cyclic projective planes, some of which are given here. Conditions under which the supports of the minimum weight vectors in a duadic code constitute a projective plane are described.

Diameters of Graphs: Old Problems and New Results

by

Fan R. K. Chung
Bell Communications Research
Morristown, NJ 07960

A basic problem in extremal graph theory as well as network optimization is to determine the minimum number of edges in a graph on n vertices so that the diameter (i.e., maximum distance among all pairs of vertices) remains small allowing the deletion of a small number of edges. A complementary problem is to add edges to a given graph in light of reducing the diameter. In this talk we will describe recent results on these problems including a complete solution for the case of removing one edge and new bounds for the general case of edge-deletion problems. As expected, the these results are closely related to the following results on the edge-augmentation problem (joint work with Bollobás): Namely, it will be shown that by adding a matching to a cycle, the diameter can be improved from $n/2$ to about $\log_2 n$, and by adding a matching to an expander or a Ramanujan graph, the diameter can be reduced to very close to the best possible value. Many related open problems will be mentioned.

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ABSTRACTS OF CONTRIBUTED PAPERS

(1)

MATCHINGS ORTHOGONAL TO 1-FACTORIZATIONS

J. H. Dinitz & D. S Archdeacon
University of Vermont

Let f be a 1-factorization of K_{2n}. We count the number of partial 1-factors containing exactly i edges which are orthogonal to F for i = 1,2,3,4, and 5.

(2)

An Extension of Bruen Chains

Richard A. Weida, University of Delaware

One way to obtain a new non-Desarguesian translation plane is by constructing a new spread which is not subregular. Chains of reguli in a regular spread of PG(3,q) were first introduced by Bruen as a method of obtaining a non-subregular spread. In this paper, we describe an extension of Bruen's notion of a chain of reguli. We also show that an appropriate bound on the number of reguli guarantees that the resultant spread is not subregular.

(3)

SOME APPLICATIONS OF NONCONSTRUCTIVE PROOFS FOR POLYNOMIAL-TIME DECIDABILITY

Donna J. Brown, University of Illinois, Urbana, IL
Michael R. Fellows, University of New Mexico, Albuquerque, NM
Michael A. Langston, Washington State University, Pullman, WA

In the field of concrete complexity theory, a decision problem has traditionally been shown to be in P by producing an efficient algorithm to solve an optimization version of the problem. However, recent advances by Robertson and Seymour have made nonconstructive tools available; these arguments guarantee only the *existence* of polynomial-time *decision* algorithms. We discuss the utility of these techniques by pointing out a number of problems whose complexities are not otherwise known. Moreover, various problems are shown to be *self-reducible*; namely, the decision algorithm can be used to actually devise a constructive algorithm.

(4)

SOME CONSEQUENCES OF THE HARARY-PALMER SIMILARITY PROPERTY FOR TOTAL GRAPHS

Bange, D., Barkauskas, A*., Host, L. U.W.-LaCrosse

A vertex-deleted subgraph of a total graph either has a unique set of vertices which must be adjacent to any added vertex which forms a total graph, or else any two such sets are equivalent under automorphism. It follows that total graphs have the Harary-Palmer Similarity Property: if $T(G)-u \cong T(G)-v$, then u and v are similar vertices. Corresponding results also hold for edges. As a consequence, it is shown that for total graphs with at most one isolated vertex, the vertex-deleted subgraphs of T(G) are pairwise nonisomorphic iff the edge deleted subgraps of T(G) are pairwise nonisomorphic, and if the vertex-deleted subgraphs of G are pairwise nonisomorphic, then the vertex-deleted subgraphs of T(G) are pairwise nonisomorphic. Again the corresponding result for edges also holds.

ABSTRACTS OF CONTRIBUTED PAPERS

(5)

On n-Divisible Subsequences

Sydney Bulman-Fleming† and Edward T.H. Wang*
Wilfrid Laurier University, Waterloo, Ontario, Canada, N2L 3C5

It is well-known that any set of n integers contains a non-empty subset the sum of whose elements is a multiple of n. Calling such a subset n-divisible, the object of this paper is to study the number f(S) of n-divisible subsets possessed by a given n-element set S. While a complete analysis of the function f appears to be out of reach, it is shown that the two largest and two smallest possible values of f(S) are $2^n - 1$, $2^{n-1} - 1$, and 1, 2, respectively, and the nature of the sets S yielding these values is completely determined. Several conjectures related to the function f are also presented.

†Research supported by Natural Sciences and Engineering Research Council of Canada Grant No. A4494.

*Research supported by Natural Sciences and Engineering Research Council of Canada Grant No. A9121.

(7)

"Optimal Enclosing Regions in Planar Graphs"

by D. Bienstock and C. L. Monma, Bell Communications Research, Morristown, NJ 07960

ABSTRACT

Consider a planar graph G=(V,E) together with a special subset D of vertices and weights on the edges. The problem is to find a region of minimum weight which contains all of the vertices in D. We show how to solve this problem in the case where an embedding is given, and in the case where the best embedding is to be found. This provides a means of recognising a class of planar graphs for which the steiner tree problem can be solved in polynomial time. A closely related problem is shown to be NP-Complete.

(6)

Symmetries of Some Drawings of Cycles

Sam Stueckle, University of Idaho

Using a given permutation, a cycle on n points evenly spaced around the unit circle may be drawn. The author will characterize the group of symmetries of this drawing under flips and rotations. This result may be extended to symmetries of pairs of cycles.

(8)

On recognising and reconstructing a tree from a subset of the deck

Wendy Myrvold, University of Waterloo

A *vertex-deleted subgraph* G_v of a graph G is obtained from G by deleting v and all edges incident to v. The family of vertex-deleted subgraph of G is called the deck. A graph G is *reconstructible* from a subset F of the deck if F is not a subset of the deck of any graph nonisomorphic to G. Infinite families of graph pairs are given that show that a tree can have approximately $\nu/3$ cards in common with a disconnected graph or with a connected unicyclic graph (where ν is the number of vertices). We also show that two nonisomorphic trees can have a common subset of size approximately $\nu/2$. Finally, it is conjectured that a tree is recognizable given any subset with at least $\left\lfloor \frac{\nu+7}{3} \right\rfloor + 1$ cards and reconstructible given at least $\left\lfloor \frac{\nu}{2} \right\rfloor + 1$. Computer results for small graphs and the infinite families given tend to support this conjecture.

ABSTRACTS OF CONTRIBUTED PAPERS

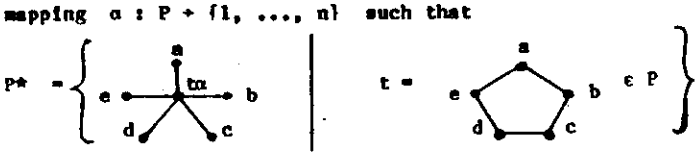
(9)

Nesting Pentagon Systems

C. C. Lindner and C. A. Rodger* Auburn University

In recent years, the nesting problem for triple systems has proved to be an interesting and stimulating problem. After some preliminary results, Doug Stinson constructed a Steiner triple system of every order $n \equiv 1 \pmod 6$ that can be nested.

In this paper we consider the nesting of pentagon systems. A pentagon system is a pair (K_n, P) where P is a collection of edge-disjoint cycles of length 5 which partition the edges of K_n, the complete graph with vertex set $\{1, \ldots, n\}$. A nesting of (K_n, P) is a mapping $\alpha : P \to \{1, \ldots, n\}$ such that



is an edge-disjoint decomposition of K_n. We prove that, with possibly 12 exceptions, the spectrum of pentagon systems which can be nested is $n \equiv 1 \pmod{10}$.

(11)

Finding a Minimum Base for Permutation Groups is NP-hard

Kenneth D. Blaha
University of Oregon

A base and strong generating set were defined by Sims in 1970, and used as an efficient method to store and analyze large permutation groups. Since then the base and strong generating set have played a key role in the development of numerous group theoretic algorithms. The base has also been used in network theory and backtrack search algorithms. The size of the base has a direct effect on the space and time complexity of these algorithms.

Given generators for a permutation group G on n letters, a greedy algorithm was suggested for finding a minimum base for G in polynomial time. We show that the greedy algorithm fails to always find a minimum base for G. Moreover, the corresponding decision problem (does there exists a base for G of size no more than K) is **NP**-complete, even if G is restricted to be a cyclic group or an abelian p-group.

(10)

ON THE PROJECTION OF COMBINATORIAL POLYHEDRA

Egon Balas, Carnegie Mellon University

It is often useful to look at representations of a given combinatorial structure in different spaces. Sometimes a polyhedron $P \subset R^n$ defined by a system of 2^n inequalities can be replaced by a polyhedron $P^* \subset R^p$ defined by a system of q inequalities, with both p and q polynomial in n. At other times p or q may not be polynomial in n, but P^* may have a nicer structure than P. The ability to move from one representation to another is therefore often very helpful. We discuss instances in which a higher dimensional representation can be used via projection to prove properties of a lower dimensional polyhedron.

(12)

COLLECTIONS OF SETS AND INTRACTABLE PROBLEMS IN RELATIONAL DATABASES

Dan A. Simovici, University of Massachusetts at Boston
Corina Reischer*), Université du Québec à Trois-Rivières

Starting from the notion of FD system previously introduced in : Jurgensen, H. and Simovici, D.A. : Towards an Abstract Theory of Integrity Constrains in Relational Databases, TR-1/85, University of Massachusetts at Boston, to appear in Information Sciences, we attach several such systems to collections of subsets of a given sets. This allows us to transport intractable problems from the combinatorial set theory to the design theory of relational database systems.

ABSTRACTS OF CONTRIBUTED PAPERS

(13)

Optical Orthogonal Codes and Difference Families

Ernie F. Brickell and *Victor K. Wei*
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A (v, k, ρ) *optical orthogonal code* is a family of k-sets of integers mod v such that $|(a+X) \cap Y| \leq \rho$ for any sets X, Y and any integer a except when $X = Y$ and $a \equiv 0 \pmod v$. An optical orthogonal code is *optimal* if its size is the largest possible. It is *perfect* if its size meets the Johnson upper bound. Perfect $(v, k, 1)$ optical orthogonal codes are the same as difference families with $\lambda = 1$. We present recursive and direct methods to construct perfect, optimal, and near optimal codes for a variety of parameters (mostly for $\rho = 1$). In particular, we present a direct construction method for $v \equiv 1 \bmod 72$, $k = 4$, $\rho = 1$ that is near optimal but fails by missing just two sets. The study of optical orthogonal codes is motivated by an application in fiber optical communications.

(14)

Guillotine cut of a rectangle and its applications

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A rectangle R consists of several small rectangles. Each small rectangle has a unique color. Let m be the total length of boundaries between those small rectangles. When we divide R into small chomatic pieces by a sequence of guillotine cuts, the total length of cuts ℓ must be bigger than m. What is the upper bound for the ratio ℓ/m. In this paper, we investigate this problem with some applications.

(15)

An efficient way for edge-connectivity augmentation

Toshimasa Watanabe* Hiroshima University, Japan

The problem in which the object is to add a minimum number of edges to a graph so as to satisfy a given edge-connectivity condition is called the edge-connectivity augmentation problem. The characterization of such minimum number, which had been one of open problems in graph theory, was solved by the author, whose proof also proposed a polynomial time algorithm for finding a minimum solution of the problem.

This paper presents some useful results to make this algorithm more efficient.

* staying at University of Illinois at Urbana-Champaign

(16)

ON THE TOPOLOGICAL STRUCTURE OF DATABASES

Ki H. Baik, Dept of EECS, Univ of Wisconsin, Milwaukee, WI

In database theory the structure of data constraint is a major issue to solve database design problems. The structure of data constraint is formally defined as a binary relation over the topology in a finite topological space or over the ring in a finite Borel space. From this topological view, representation for keys and time complexity measure for database design problems are introduced. With a formal definition for key related database design problems which are NP-complete, the key representation classifies the category of database design problems. Under this classification, we identify polynomial time complexity problems for certain subcategories.

ABSTRACTS OF CONTRIBUTED PAPERS

(17)

A DOUBLE AFFINE PLANE OF ORDER 6

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Ft. George G. Meade

A Balanced Incomplete Block Design (BIBD) with parameters $(v, k, \lambda, r, b) = (36, 6, 2, 14, 84)$ is constructed. This is the first BIBD with these parameters to be constructed *without repeated blocks*. In fact, it has $P\Gamma L(2, 8)$ as an automorphism group acting transitively on the blocks and with rank three on the points.

(19)

Edge Deletion Problems: Properties defined by Weakly Connected Forbidden Graphs

Ehab S. El-Mallah* and Charles J. Colbourn
University of Waterloo

The edge deletion problem (*EDP*) associated with a given graph property is to find the minimum number of edges whose deletion results in a subgraph satisfying that property. Yannakakis has shown a number of *EDP*s are NP-complete. Watanabe, Ae and Nakamura obtained a unified NP-completeness result for properties defined by a finite set of 3-connected forbidden minors. Asano and Hirata extended the previous result to nontrivial properties that are hereditary on subgraphs and are determined by the 3-connected components. In this paper we address the complexity of some *EDP*s on properties defined by a set F of forbidden induced subgraphs, homeomorphs or minors. We investigate some cases when F contains some graph of a small connectivity. In particular, we show that the *EDP* is NP-complete for each of the following cases of F.

(i) F is a set of forbidden homeomorphs or minors in which every member is a 2-connected graph with minimum degree 3.

(ii) F contains K_4-e as a single forbidden homeomorph or minor.

(iii) F contains P_l, $l \geq 3$, the simple path on l vertices, as a single forbidden induced subgraph.

The first result generalizes Watanabe et. al. result and extends Asano and Hirata's result for hereditary properties. Moreover, results (ii) and (iii) show that finding a maximum cactus subgraph and cograph are NP-hard, respectively.

(18)

EFFICIENT DOMINATION OF GRID GRAPHS

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P. Slater, U. of Alabama in Huntsville

A vertex in a graph *dominates* its neighbors. A *dominating set* for a graph G is a set of vertices of G such that every vertex of G is either in the dominating set or is dominated by a member of the set. If none of the members of the set are adjacent and if no vertex of G is dominated by more than one member, then the dominating set is *efficient*.

Up to symmetry there is a unique way to choose an efficient dominating set for unbounded planar grid graph. We refer to this as the *tiling pattern*. With few exceptions, it is impossible to efficiently dominate an n x m grid so we look for a maximal subgraph which can be efficiently dominated, minimizing the number of vertices which are undominated. If the grid is 9 x 9 or larger we show that the tiling pattern leaves $2i + 2j + k$ vertices undominated where $n = 5i + r$, $m = 5j + s$ and $k \in \{0,1,2\}$ depends on r and s and that no other efficient dominating set can do better. We also discuss special strategies for smaller grids.

(20)

BIPARTITE ANALOGS OF GRAPH THEORY

Terry McKee, Wright State University, Dayton Ohio

Many people have investigated possible bipartite analogs of various graph-theoretic properties in the hope of producing bipartite theorems analogous to those for ordinary graphs. We look at a very simple, general way of doing this which is completely independent of the particular formulation of the original property, and for which a large family of graph-theoretic theorems have automatic bipartite analogs.

ABSTRACTS OF CONTRIBUTED PAPERS

(21)

Vanstone's Construction Applied to GBRDs

Jennifer Seberry, University of Sydney

Vanstone's Construction is used to form new GBRDs. These are then used to form new families of BIBDs.

(22)

Maximal Clique-Separators of Chordal Graphs

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S. Sitharama Iyengar, Louisana State University

A maximal clique-separator of a chordal graph is a clique-separator which is not properly contained in any other clique-separator. We study the interrelationships of maximal cliques and maximal clique-separators. Among other results necessary and sufficientionditons for a maximal clique-separator to be a maximal clique are given.

(23)

Network Resilience and Broadcasting in Unreliable Networks

Louis D. Nel
University of Waterloo

Broadcasting in a communications network is the process of disseminating information to all network nodes. In an unreliable network, proper selection of the node from which to broadcast can have a great impact on the dissemination process. The *resilience* of an unreliable network is the expected number of node pairs which can communicate; *Broadcast resilience* is the expected number of nodes reachable from a particular broadcast node. Computing network resilience is *#P-complete*, moreover, exhibiting the least resilient i-edge subgraph is *NP-hard*. For the network broadcast function, the node with the greatest broadcast resilience should be selected. Finding the network node with the greatest broadcast resilience is, however, *NP-hard*. Heuristic selection of the broadcast node introduces some interesting heuristic design problems.

(24)

Bipartite Permutation Graphs

A. Brandstadt, J. Spinrad and L. Stewart *

A graph G is a permutation graph iff both G and its complement are transitively orientable; a bipartite graph has the property that it can be partitioned into two parts such that each part induces an independent set in the graph. The intersection of these two classes of graphs is the family of bipartite permutation graphs. We examine structural characterizations and algorithmic properties of bipartite permutation graphs, and show their relation to some other bipartite graph families.

ABSTRACTS OF CONTRIBUTED PAPERS

(25)

CLEAN TRIANGULATIONS

Nora Hartsfield, University of California, Santa Cruz, CA 95064
Gerhard Ringel, University of California, Santa Cruz, CA 95064

A poylhedron on a surface is called a clean triangulation if each face is a triangle and each triangle is a face. Let S_p (resp. N_p) be the closed orientable (resp. non-orientable) surface of genus p. If (S) is the smallest possible number of triangles in a clean triangulation of S, the results are:

(26)

ON INTERSECTING MAXIMAL ARCS

JOEL C. FOWLER, GEORGIA INSTITUTE OF TECHNOLOGY

We investigate the number of points that two maximal arcs may have in common.

(27)

Reliable Minimum-Time Broadcast Networks

Arthur M. Farley, University of Oregon

The specification of a communications network requires both a topological and an operational aspect. The topological aspect consists of a graph representing the sites and their interconnection by lines. The operational aspect consists of calling schemes that complete various communication tasks. In earlier research, we specified several classes of minimum-time broadcast networks through topological and operational aspects sufficient to allow completion of the one-to-all broadcast task from any site as originator in the minimum possible time (i.e., $\log_2 n$ time units for n sites).

Here we present extensions to the operational specification of one of these classes to realize broadcast networks that are also immune to isolated failures. In such networks, broadcast is completed to all operating sites in the presence of failure sets that do not contain "neighboring" components. Furthermore, a broadcast suffers the minimum possible delay of at most one time unit for each failing component encountered.

(28)

Random Graphs with the Distance-Hereditary Property

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Baruch College (CUNY), New York NY 10010

A graph G is distance-hereditary if for all connected induced subgraphs F of G the distance between any given pair of vertices in F is the same as in G. Based on Howorka's result we first present a more useful (for our purpose) characterization of distance-hereditary graphs. Next, we consider a random graph model $K_{n,p}$ which is a random subgraph of a complete graph K_n obtained by removing edges, each with the same probability 1-p, independently of all other edges. The probability of the event that a random graph $K_{n,p}$ is distance-hereditary is examined in detail for the whole range of edge probabilities p = p(n) and sufficiently large n.

ABSTRACTS OF CONTRIBUTED PAPERS

(29)

COSTAS ARRAYS AND A SHIFTING PROPERTY OF ITS DIFFERENCES

Oscar Moreno, University of Puerto Rico

There is a conjecture of Golomb and Taylor that asserts that the Welch construction for Costas Arrays, with length p-1, p prime, is the only one with property of single periodicity.

In the present paper, we present a weaker conjecture: the Welch construction is the only one with the property that its differences are a shift of the original array. We also give proof of this conjecture.

(30)

Independence and Other Properties for Integer Interval Graphs and Their Complements

Ralph P. Grimaldi, Rose-Hulman Institute of Technology

For any positive integer n the integer interval graph G_n is constructed as follows:

(Vertices) If $0 \leq m < p \leq n$, with m,p integers, then the closed interval $[m,p]$ determines a vertex of G_n.

(Edges) For integers i,j,m,p with $0 \leq i < j \leq n$ and $0 \leq m < p \leq n$, there is an edge joining the vertices determined by $[i,j]$ and $[m,p]$ if these intervals have a nonempty intersection.

This article examines properties of G_n (and $\overline{G}_n$) dealing with vertex independence. In particular, the number of triangles in G_n (independent three-sets in $\overline{G}_n$) is derived and the number of edges in G_n is determined from the independent two-sets of the graph. Certain identities are also derived from various properties of these graphs and their complements.

(31)

THE FLOW OF CONTROL, DATA, AND DEVELOPMENT IN SOFTWARE

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Lafayette, LA 70504-4330

The essential information transfer of the software design process is normally viewed in terms of two closely related flow graphs. The first is the traditional control flow graph, which represents the anticipated execution of the program by a single processor. The second is a data flow or data dependency graph, which represents the information transformation from input data to output data, through the variables of a single module, and at a higher level through the modules of a software system. But it is important to note that the flow of information as seen by the developer and maintainer of a piece or a system of software is distinct from, though dependent upon, these two flow graphs.

An abstract model of the development process is defined in terms of the space of live names and tools that the developer manipulates and the record, executable and nonexecutable, that the developer generates. Relationships of this model to the information flow of the program are derived and implications for the measurement and control of software complexity are explored. Critical questions include the information content of a flow graph and the goodness of approximation of one flow graph by another.

(32)

The Difference Between A Neighborhood Graph And A Wheel

James W. Boland*
Robert C. Brigham
Ronald D. Dutton
University of Central Florida

For any graph G we define its neighborhood graph N(G) as the graph on the same node set with two nodes adjacent if and only if they have a common neighbor in G. It is well known that not all graphs are neighborhood graphs. We define g(H) to be the smallest integer for which there is a graph G on g(H) nodes such that N(G) contains H as an induced subgraph. The values g(H) are calculated when H is a wheel on p nodes, $p \geq 5$.

ABSTRACTS OF CONTRIBUTED PAPERS

(33)

CODES ASSOCIATED TO INTERSECTION PROPERTIES OF THE GRASSMANN VARIETIES G(3,6) AND G(3,7)

Charles Ryan — University of Lowell

In this paper we will further investigate the linear block codes C(3,6) and C(3,7) associated to the Grassmann Varieties G(3,6) and G(3,7). In particular C(3,6) will be defined as the linear span of those Boolean functions $\Phi(p^*) \mid G(3,6) \longrightarrow Z(2)$ which evaluate to 1 on $G(3,6) \setminus \Omega(p^*)$ where $\Omega(p^*) = \{p \in G(3,6) \mid p \cap p^* = (0)\}$ p^* being a distinguished point of G(3,6).

After projectively realizing G(3,6) in P(19) linear dependencies associated to particular Schubert Varieties as well as techniques based on the geometry of G(3,6) are developed and used in turn to determine first, the external distance of C(3,6) and secondly its weight distribution in terms of the Orthogonal Krawtchauk Polynomials.

(34)

Some Results on the Achromatic Number of a Graph.

R. Rowley*, C. Turner, R. Jamison and R. Laskar, Clemson University, Clemson, SC 29634

An n-coloring of a graph G = (V, E) is a function f from V onto N = {1, 2, ..., n} such that, whenever vertices u and v are adjacent, then $f(u) \neq f(v)$. An n-coloring is complete if for every pair i, j of integers $1 \leq i \leq j \leq n$, there exists a pair u, v of adjacent vertices such that f(u) = i and f(v) = j. The chromatic numbers $\chi(G)$, and the achromatic number, $\Psi(G)$, are the smallest and largest values n, respectively, for which G has a complete n-coloring. A complete n-coloring $g: V \rightarrow N$ is a Grundy coloring if for every vertex $v \in V$, g(v) is the smallest integer which is not assigned to any vertex adjacent to v. The Grundy number, $\Gamma(G)$, is the largest n for which G has a Grundy n-coloring. It is well-known, that $\chi(G) \leq \Gamma(G) \leq \Psi(G)$, for any graph G. This paper studies $\Psi(L(K_n))$, where $L(K_n)$ is the line graph of complete graph on n vertices. In particular, bounds for $\Psi L(K_n)$, $n \leq 14$ are given.

(35)

PARAMETERS WHICH MEASURE THE VULNERABILITY AND RELIABILITY OF GRAPHS

K.S. Bagga, L.W. Beineke, M.J. Lipman*, R.E. Pippert
Indiana University-Purdue University at Fort Wayne

We suggest a classification scheme for all parameters purporting to measure the strength of a graph. A large, but incomplete set of such measures is sorted using the scheme. A partial classification as a vertex or edge measure and as a vulnerability or reliability measure groups parameters into sets of size four. For example, edge connectivity, vertex connectivity, and all-terminal reliability are correspondents. The fourth correspondent is both the vertex analog of all-terminal reliability and the probabilistic analog of vertex connectivity. This parameter is as yet unexplored. The classification scheme suggests many natural measures which might prove useful.

(36)

Families of Primal Graphs with Maximum Degree 3

Phyllis Z. Chinn, Humboldt State University
R. Bruce Richter, U.S. Naval Academy
Miroslaw Truszczynski, University of Kentucky
(on leave from the Institute of Mathematics, Technical University of Warsaw, Poland)

It has previously been shown that there is a unique set π of primal graphs such that every graph has an edge-decomposition into non-isomorphic elements of π and that the only decomposition of an element of π into non-isomorphic elements of π is the trivial one. Here we prove the existence of infinite numbers of new primal graphs having maximum degree 3 and a relatively simple structure. We also show "most" of the graphs having the specified structure are not primal.

ABSTRACTS OF CONTRIBUTED PAPERS

(37)

DUADIC CODES AND CYCLIC PROJECTIVE PLANES

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The definition of duadic codes and Q-codes (Pless, et al.) is generalized to arbitrary finite fields. That is, $(n, \frac{n+1}{2})$ and $(n, \frac{n-1}{2})$ cyclic codes are defined by means of their idempotents and an integer t relatively prime to n. All of the properties of the binary and GF(4) cases extend. In particular, if $t = -1$, conditions are given for the minimum weight vectors to span a cyclic projective plane. Conversely, any cyclic projective plane of prime power order is shown to be embeddable in some duadic code.

(38)

Interpolation Theorems for Invariants of Spanning Trees of a Given Graph: Edge-coverings

Frank Harary
New Mexico State University

Seymour Schuster
Carleton College

Abstract

The edge-edge covering number $\alpha_{11}(G)$ of a graph G is the smallest number of edges that cover the edge-set of G. This, the third in a series of papers devoted to the study of interpolation theorems for invariants of spanning trees of a graph, contains a proof that α_{11} interpolates in the following sense: If m and n are the minimum and maximum values (respectively) of $\alpha_{11}(T)$ over all spanning trees T of a given graph H, then for any k, $m < n < k$, there is a spanning tree T^* of H such that $\alpha_{11}(T^*) = k$. This result was conjectured by the authors in an earlier paper which studied all the covering numbers with the exception of the elusive α_{11}. Hence, the study of interpolation results for covering numbers is now complete.

(39)

Exact Formulas for Reliability Measures for Various Classes of Graphs

Ashok T. Amin, Kyle T. Siegrist,* Peter J. Slater
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Consider a probabilistic graph $G = (V,E)$ in which each edge $e \in E$ fails, independently of all others, with probability q $(0 < q < 1)$. Reliability measures for such graphs include the probability that two specified vertices are connected, the expected number of pairs of vertices connected, and the expected size of the component containing a given vertex. In this paper, the computation of these reliability measures for the graph $G+x$ is reduced to the computation of the reliability measures, and other statistics, for the graph G. This reduction method is used to obtain explicit, rational formulas for the reliability measures of such graphs as wheels, fans, and diamonds. Asymptotic results are also obtained.

(40)

Highly Irregular Digraphs

Michael L. Gargano,* Pace University
Louis V. Quintas, Pace University

The degree of a vertex V in a directed graph is the ordered pair (indegree (V), outdegree (V)). In a highly irregular digraph no two vertices have the same degree. Some properties of these digraphs will be discussed.

ABSTRACTS OF CONTRIBUTED PAPERS

(41)

Authentication Codes that Permit Arbitration*

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The objective of authentication is to detect attempted deceptions in a communications channel. Traditionally this has meant providing the authorized receiver(s) with the capability of detecting unauthentic messages, i.e., messages originated by unauthorized transmitters, or else authentic messages that have been intercepted and modified before being relayed on to the receiver. Simmons, Brickell, Stinson and others have devised authentication codes that realize this limited capability, but only subject to the severe constraint that the transmitter and receiver had to be assumed to act with the joint purpose of detecting attempted deceptions by outsiders and that neither would attempt to deceive the other. This constraint was necessary since the only codes devised thus far have required each of them to know the same secret (from the opponent) information, and hence to have interchangeable capabilities. The unavoidable consequence of this has been that authentication codes permitted either the transmitter to disavow an authentic message that he actually sent to the receiver or else the receiver to falsely attribute a message of his own devising to the transmitter. Of course the party being deceived would know that he was the victim of a deception by the other, but he would be unable to "prove" this to a third party. Ideally, authentication should provide a means to detect attempted deceptions by insiders (the transmitter or receiver) as well a outsiders (the opponent). It has been an open question of whether it was possible to devise authentication codes that would permit a third party, the arbiter, to detect either the transmitter or receiver cheating. We answer this question in the affirmative by constructing an example of an authentication code that still permits the receiver to detect outsider deceptions, but that also permits a designated arbiter to detect insider deceptions.

* This work performed at Sandia National Laboratories supported by the U. S. Dept. of Energy under contract no. DE-AC04-76DP00789.

(43)

TREE REALIZATION OF DISTANCE DEGREE SEQUENCES

A. T. Amin*, K. T. Siegrist, and P. J. Slater
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ABSTRACT Let G be a graph with n vertices. For a vertex v, $d_j(v)$, 1 <= j <= n-1, denotes the number of vertices at distance j from v. The sequence $(d_1(v), d_2(v), \ldots, d_{n-1}(v))$ is called the Distance Degree Sequence (DDS) of v in G. Thus, $d_1(v)$ is simply the degree of v in G. The set of DDSs of vertices in a tree play an important role in determining reliability of tree structures. Given a set D of n sequences, the problem of realization of D as a set of DDSs of a tree with n vertices is considered.

(42)

DIAMETER AND THE EDGE INTEGRITY OF GRAPHS

K.S. Bagga*, L.W. Beineke, M.J. Lipman, R.E. Pippert
Indiana University-Purdue University at Fort Wayne

The edge integrity of a graph G is defined as $\min\{|S| + m(G - S)\}$, where S is a set of edges of G and m(G - S) is the order of a largest component of G - S. We compute the edge integrity of certain classes of graphs. Among our results, we prove the following: If G is a graph of order p and diameter two, then the edge integrity of G is p. We also give examples to show the sharpness of this result.

(44)

On an Inequality for Cubic Graphs

William A. Waller
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Let G be a simple graph with maximum degree p, and let I be a maximum independent set of vertices of G. For i=0,1,2,...,p let $G_i(I)=G_i$ denote the set of vertices of G adjacent to exactly i vertices in I. Under various conditions on the girth and maximum clique size of G, the relative sizes of these classes can be used to establish lower bounds for the independence ratio of G. In this paper we show that if G is cubic and triangle-free, and I is chosen so that $|G_3|$ is maximized, then $|G_1| \leq 5|G_3|$. This is an improvement on the best previously known bound, namely $|G_1| \leq 6|G_3|$. We also discuss the conjecture $|G_1| \leq 2.5|G_3|$, and we review how these inequalities can be used to establish lower bounds for the independence ratio of G.

ABSTRACTS OF CONTRIBUTED PAPERS

(45)

Projective Spaces in Projective Planes

Lynn M. Batten   University of Winnipeg

The situation of a projective plane of order m sitting 'naturally' inside a projective plane of order n, $m<n$, was first considered in detail by Bruck 1963. His main result, connecting m and n, is that either $n=m^2$, in which case each line of the large plane meets the small plane, or $n \geq m^2+m$. Here we consider a projective space PG(d,m), $d \geq 3$, sitting inside a projective plane of order $n>m$. We prove that lines missing the PG(d,m) always exist in this case. Moreover, for $d=3$, we give some specific results relating m and n.

(47)

SYNCHRONIZABLE CODES IN THE N-CUBE

L. J. CUMMINGS, UNIVERSITY OF WATERLOO

Those binary strings which are lexicographically least in the aperiodic classes obtained by cyclic permutation of all binary strings of length n under cyclic permutation form a code of bounded synchronization delay. The structure of these codes as sets of vertices in the n-cube is studied.

(46)

DISSECTION OF EQUILATERAL TRIANGLES

DR. CRAIG BAILEY, U.S. NAVAL ACADEMY

We will consider the problem of dissecting an equilateral triangle into the minimum number of smaller not necessarily different sized, equilateral triangles. Arithmetic constraints on the sizes of the component triangles will be used to generate necessary conditions for a dissection to be minimal. Some sufficiency conditions in special cases will be looked at.

(48)

SEARCH ALGORITHM FOR RAMSEY GRAPHS BY UNION OF GROUP ORBITS

STANISŁAW P. RADZISZOWSKI and DONALD L. KREHER

School of Computer Science and Technology
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ABSTRACT: An algorithm for the construction of Ramsey graphs with a given automorphism group G is presented. To find a graph on n vertices with no clique of k vertices, K_k, and no independent set of l vertices, $\overline{K}_l$, $k,l \leq n$, with an automorphism group G, a Boolean formula α based on the G-orbits of k-subsets and l-subsets of vertices is constructed from incidence matrices belonging to G. This Boolean formula is satisfiable if and only if the desired graph exists, and each satisfying assignment to α specifies a set of orbits of pairs of vertices, whose union gives the edges of such a graph. Finding these assignments is basically equivalent to the conversion of α from CNF to DNF (conjunctive to disjunctive normal form). Though the latter problem is NP-hard, we present an "efficient" method to do the conversion for the formulas that appear in this particular problem. When G is taken to be the dihedral group D_n for $n \leq 101$, this method matches all of the previously known cyclic Ramsey graphs as reported by Chung and Grinstead in their survey paper (*J. Graph Theory*, vol.7, no.1 1983, 25-38), in dramatically smaller computer time when compared to the time required by an exhaustive search. Five new lower bounds for the classical Ramsey numbers are established: $R(4,7) \geq 47$, $R(4,8) \geq 52$, $R(4,9) \geq 69$, $R(5,7) \geq 76$ and $R(5,8) \geq 94$. Also, some previously known cyclic graphs are shown to be unique up to isomorphism.

ABSTRACTS OF CONTRIBUTED PAPERS

(49)

CLOSED ARCS IN FINITE PROJECTIVE PLANES

William Cherowitzo
University of Colorado at Denver

Closed arcs (immersed B-ovals) have recently been studied by a number of Italian geometers. Most of their results have been obtained in the Desarguesian case. In this paper we will survey this work and provide an example of a closed arc in the Hughes plane of order 9 which has properties unlike those of a closed arc in a Desarguesian plane.

(51)

Improvements of Gibbs-Poole-Stockmayer Bandwidth Reduction Algorithm

J. Opatrny, Concordia University, Montreal

The bandwidth problem is known to be NP-complete and, therefore, polynomial algorithms which compute an approximation of the bandwidth are used in practice. From these 'bandwidth reduction' algorithms, the Gibbs-Poole-Stockmayer algorithm has been most widely used. A faster implementation of the algorithm was done by J.G. Lewis. In this talk we will discuss what changes can be done in the Gibbs-Poole-Stockmayer algorithm in order to improve the bandwidth reduction for many families of graphs.

(50)

Transformations of Polygonal Triangulations

Barry Nolin, University of Ottawa.

An elementary operation on a triangulation of a simple polygon, corresponding to a binary tree rotation, is that of flipping a diagonal to obtain a new triangulation of the polygon. Given two triangulations T_1, T_2 of a simple polygon P of order n, can we find a sequence of diagonals flips from T_1 to T_2 ? Some definitions and elementary results are given and an asymptotically optimal algorithm which is $O(n^2)$ in terms of the number of "flips" required for the simple n-gon. Also given are algorithms for the convex case which have O(n) flip complexities.

(52)

A New Proof of the Ringel Theorem

Henry H. Glover

In this paper we give a new proof of the Ringel Theorem extending the four color Theorem to nonorientable surfaces:

$$n(\tilde{S}_g) = [\frac{7 + \sqrt{1 + 24g}}{2}] , \quad g \neq 2 .$$

Here $\tilde{S}_g$ denotes the nonorientable surface of genus g, n denotes the number of colors needed and [ ] denotes the integer part. We follow Ringel and reduce the problem to that of computing the nonorientable genus of the complete graph K_n. We show

$$\text{genus}(K_n) = \{\frac{(n-3)(n-4)}{6}\} , \quad n \neq 7 .$$

Here { } denotes the integer hull. For this we prove a general cycle assignment theorem which states that certain obvious necessary conditions about the assignment of the cycles in a graph to those of a surface given by an embedding of the graph in the surface are also sufficient conditions. We then apply this theorem to the case of a complete graph using results about (in)complete triple systems. The proof of the cycle assignment theorem uses a characterization of graph embedding in terms of maps from the configuration space of the graph to that of the surface.

ABSTRACTS OF CONTRIBUTED PAPERS

(53)

Partitions into indecomposable triple systems

Charles J. Colbourn and Janelle J. Harms*
University of Waterloo

The indecomposable partition problem is to partition the set of all triples on v elements into s indecomposable triple systems, where the ith triple system has index λ_i and $\lambda_1 + \cdots + \lambda_s = v-2$. A complete solution for $v \leq 10$ is given here. Extending a construction of Rosa for large sets, we then give a $v \rightarrow 2v+1$ construction for indecomposable partitions. This recursive construction employs solutions to a related partition problem, called indecomposable near-partition. A partial solution to the indecomposable near-partition problem for $v=10$ then establishes that for every order $v = 5 \cdot 2^t - 1$, all indecomposable partitions having $\lambda_i = 1,2$ for each i can be realized.

(54)

On Pólya-de Bruijn's Theorem

C. Y. Chao, University of Pittsburgh

Let D and R be two nonempty finite sets, R^D be the set of all functions from D into R, G be a permutation group acting on D, H be a permutation group acting on R, and a relation ~ be defined on R^D such that $f \sim g$ if and only if there exist a $\sigma \in G$ and a $\tau \in H$ with $f(\sigma d) = \tau g(d)$ for all $d \in D$. Since this relation is an equiva-lence relation, R^D is partitioned into disjoint equivalence class-es. By using the cycle indicies of G and H, de Bruijn's theorem determines the number of the equivalence classes. If H is the iden-tity group, then by using the cycle index of G and "weights", Pólya's theorem gives the function counting series.

Here we present an algorithm for obtaining the equivalence classes in R^D, i.e., our algorithm determines which functions in R^D belong to the same equivalence class. Our algorithm does not use the cycle indicies of permutation groups; it only depends on the idea of an incidence matrix of a function and on the permutation groups. Consequently, by using our algorithm, we may obtain the results of Pólya and de Bruijn for any given R^D, G and H.

(55)

Chromatic properties of graphs with up to 10 vertices

Ronald C. Read
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Abstract. The existence of a catalogue of graphs on 10 or fewer vertices makes it possible to study exhaustively the chromatic properties of these graphs using a computer. Some information thus obtained is presented, including statistics on chromatic uniqueness, chromatic equivalence and chromatic number.

(56)

A Topological Parameterization and Hard Graph Problems

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F. Hickling, Math. Dept., Univ. of California, San Diego
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Graphs which embed on a surface S of genus g can be parameterized by the minimum number k of disjoint open disks such that G can be embedded on S minus k open disks so that the vertices of G all lie on the boundary of the resulting surface. This disk dimension of graphs interacts in interesting ways with genus. It is shown that determining the disk dimension of a planar graph is NP-complete. For each fixed k determining whether G has planar disk dimension no more than k can be done in polynomial time. A simple algorithm is developed for planar disk dimension two. It is shown that several problems which are NP-complete for planar graphs can be solved in polynomial time for graphs of bounded disk dimension.

ABSTRACTS OF CONTRIBUTED PAPERS

(57)

Pairwise Balanced Designs with Prime Power Block Sizes Exceeding 7

F.E. Bennett, Mount Saint Vincent University

Abstract: In this paper, we construct pairwise balanced designs (PBDs) having block sizes which are prime powers exceeding 7. If we denote by P^* the set of all prime powers exceeding 7 and by $B(P^*)$ the set of orders of PBDs of index unity having block sizes from P^*, then it is shown that $v \in B(P^*)$ for all $v > 2206$ and for many orders less than this value. We also give some applications to the construction of other types of combinatorial designs, such as conjugate orthogonal Latin squares and sets of mutually orthogonal Latin squares (MOLS). For example, it is proved that the spectrum of idempotent Latin squares with distinct and pairwise orthogonal conjugates contains all orders v mentioned above, and some of the PBDs constructed in this paper can be used to obtain more MOLS of certain orders than previously known.

(58)

Hidden Polynomials

Heinrich Niederhausen, Florida Atlantic University, Boca Raton FL 33431

In enumeration one frequently encounters polynomials $b_n(x)=\Sigma b_{n,i}x^i$ of *binomial type* , i.e. satisfying the convolution identity $b_n(x+y)=\Sigma b_i(x)b_{n-i}(y)$. That identity forces an elaborate structure on the coefficients $b_{n,i}$. For instance, they also follow some convolution identity. Furthermore, we found that for fix n, the coefficients $b_{n+i,i}$ also are the values $p_n(i)$ of an n-th degree polynomial p_n in "almost all cases", and these polynomials are of binomial type. Now we show the existence of another such sequence of binomial-type polynomials q_n, having a weighted sum of coefficients $b_{n+i+j,j}$ as values $q_n(i)$. For example, this structure makes the following Stirling number identity obvious
$1 = 3k!2^k\Sigma(-1)^i s(k+i+3,i+1)/[(k+i+3)!(k-i)!]$

(59)

CUTTING A GRAPH INTO TWO DISSIMILAR HALVES.

by

Paul Erdős, Mark Goldberg*, János Pach, Joel Spencer.

ABSTRACT

Given a graph G and a subset S of the vertex set of G, the discrepancy of S is defined as the difference between the actual and expected numbers of the edges in the subgraph induced on S. We show that for every graph with n vertices and e edges, $n < e < \frac{n(n-1)}{4}$, there is an $\frac{n}{2}$-element subset with the discrepancy of the order of magnitude of $\sqrt{ne}$. For graphs with fewer than n edges we calculate the asymptotics for the maximum guaranteed discrepancy of an $\frac{n}{2}$-element subset. We also introduce a new notion called the bipartite discrepancy and discuss related results and open problems.

(60)

GRAPHS WITH CROSSING NUMBER 2

R. Bruce Richter
U.S. Naval Academy

Let G be a graph with crossing number $\mu(G)$ -- this is the least number of pairwise intersections of edges among all drawings of G in the plane. If $\mu(G) > k$, is it true that G has a subgraph H such that $\mu(H) = k$? In general, the answer is no, for $k \geq 3$. If $k = 1$, then the answer is yes. In this talk, we consider the case $k = 2$.

ABSTRACTS OF CONTRIBUTED PAPERS

(61)

ON THE STEINER SYSTEMS S(2,4,25) INVARIANT UNDER A GROUP OF ORDER 9

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V.D.Tonchev, Bulgarian Academy of Sciences

We establish that there are exactly five non-isomorphic Steiner systems S(2,4,25) invariant under a group of order 9. These designs and all other S(2,4,25)'s known to us are presented along with their full automorphism groups and block-graph invariants.

(63)

RECOGNIZING CIRCULAR-ARC GRAPHS THROUGH TRANSFORMED DECOMPOSITION

Wen-Lian Hsu, Northwestern University

Circular-arc graphs are the intersection graphs of families of arcs around a circle. Tucker gave an $O(|V|^3)$ recognition algortihm for this class of graphs. However, the algorithm is extremely complicated and the constant in $O(|V|^3)$ is enormous. There are two major difficulties in recognizing circular-arc graphs. First of all, there can be an exponential number of arc representations for a given circular-arc graph. Secondly, the "wrap around" effect of arcs in the circle creates a lot of ambiguity in the search for a representation. In this paper, we propose the notion of "normalized representations" for circular-arc graphs, which eliminate all trivial model variations. Furthermore, by considering normalized representations, we are able to transform a given circular-arc graph into a unique circle graph. This latter graph can be recognized using the $O(|V|\cdot|E|)$ decomposition algorithm of Gabor, Hsu & Supowit. We show that when the transformed circle graph has a unique chord representation, its corresponding circular-arc graph has a unique normalized representation. Based on this, a decomposition recognition algorithm for circular-arc graphs is developed.

(62)

Random Functions and their Small Cycles*

John M. DeLaurentis, Sandia National Laboratories, Albuquerque, NM 87185

Denote by Γ_n the set of mappings from an n element set into itself and impose a uniform distribution on Γ_n, i.e., $P(\gamma) = n^{-n}$ for $\gamma \in \Gamma_n$. The directed graph which is associated with γ consists of a number of components with each component possessing a unique cycle. Define the random variable $X_n(t,m)$ to be the number of components in γ which contain at least the fraction t $(0 < t < 1)$ of the total number of nodes and such that each component's cycle has size not exceeding $m = O(n^{1/2-\varepsilon/2})$, $0 < \varepsilon < 1$. In other words, $X_n(t,m)$ counts the number of components in γ which contain a significant percentage of the total number of nodes and such that each component's cycle is relatively "small". We derive the asymptotic expression

$$P(X_n(t,m) > 1) = c(t)mn^{-1/2} + O(r_n(t)) \quad , \qquad n \to \infty \quad ,$$

where

$$c(t) = \left(\frac{2(1-t)}{\pi t}\right)^{1/2}$$

and

$$r_n(t) = t^{-1/2}n^{-\varepsilon/2-1/3} + t^{-3/2}n^{-3\varepsilon/2} + t^{-1}n^{-\varepsilon} \quad .$$

Roughly, this expression represents the probability that a "cycling experiment" will detect a "small" cycle.

(64)

The Topological Structure of the Space of Unending Paths of a Graph

Tom Head
Univ. of Alaska - Fairbanks

Let G be a finite rooted directed multi-graph. With each such G is associated an algorithmically constructed graph CF(G) of the same type. It is demonstrated that the spaces of unending paths in two finite rooted directed multi-graphs G and G′ are homeomorphic if and only if the graphs CF(G) and CF(G′) are isomorphic. It is shown that a topological space is homeomorphic with the space of unending paths in such a graph G if and only if it is compact, zero-dimensional, metrizable and of finite type.

ABSTRACTS OF CONTRIBUTED PAPERS

(65)

Covering pairs by quintuples: the case $v \equiv 3 \pmod 4$

W. H. Mills*, Institute for Defense Analyses
R. C. Mullin, University of Waterloo

Let $C(v)$ denote the least number of quintuples of a v-set V with the property that every pair of distinct elements of V occurs in at least one quintuple. Let $B(v) = \lceil v\lceil (v-1)/4\rceil\rceil$. It is known that $C(15) = B(15) + 1$. It is shown that if $v \equiv 3 \pmod 4$, $v \geq 7$, and $v \not\equiv 15$, then $C(v) = B(v)$.

(66)

TEN STEPS TO COUNTING PLANAR GRAPHS

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Abstract. This survey article collects from the literature some map-enumeration results which can be considered preliminary steps towards solving the open problems of counting non-isomorphic planar graphs and planar cubic graphs. Those results which are closed-form formulae are quoted, including several by the authors which have not been published elsewhere. Among these are a formula for the number of cubic maps up to sense-preserving isomorphisms, due to the first author, and a formula for the number of rooted 3-connected maps, found by the second author as a solution of a linear recursion due to W. T. Tutte.

(67)

GRAPH NEAR-COLORING ALGORITHMS

Sigmund N. Hudson*, Armstrong State College, and
Gomer Thomas, Clarkson University

This paper presents theoretical and experimental results on heuristic graph "near-coloring" algorithms, where the "near-coloring" problem is defined by: Given an arbitrary graph G and an arbitrary number s of available colors, assign each vertex a color in such a way as to minimize the total number of conflicts; i.e. to minimize the total number of edges whose incident vertices are the same color.

For some applications near-coloring represents a better model of the dynamics of the application than graph coloring does, for example in scheduling or compiler register allocation, where there are only a fixed number of resources (colors) available.

It has been proved by Vitanyi that the near-coloring problem is NP-complete. It is proved here that it remains NP-complete even for the restricted class of k-partite graphs.

Two classes of heuristic algorithms are investigated here: sequential and incremental improvement. Experimental results are presented from testing these algorithms on random graphs G(n,p) for various values of n and p and various values of s between 2 and the estimated chromatic number of the graphs. It is also proved that an upper bound established by Vitanyi on the total cost obtained by the incremental improvement algorithms holds for the sequential algorithms as well.

(68)

INTEGRITY OF TREES

C. A. Barefoot, New Mexico Institute of Mining and Technology, Socorro, NM
Roger Entringer*, University of New Mexico, Albuquerque, New Mexico
and
Henda Swart, University of Natal, Durban, South Africa

The *integrity* of a graph G is defined by $I(G) = \min_S(|S| + m(G-S))$ where $S \subseteq V(G)$ and $m(G-S)$ is the maximum number of vertices in any component of $G-S$. Similarly, the *edge-integrity* is given by $I'(G) = \min_S(|S| + m(G-S))$ where now $S \subseteq E(G)$. Of all trees T of order n it is apparent that $I(T)$ is minimum for $T \cong K_{1,n-1}$ and it is shown that $I(T)$ achieves its maximum value when $T \cong P_n$. In contrast, $I'(T)$ is obviously largest when $T \cong K_{1,n-1}$ and is shown to be smallest when $T \cong P_n$.

ABSTRACTS OF CONTRIBUTED PAPERS

(69)

Intersection Graphs of Semigroups II: Quasi-ideals and Bi-ideals

John K. Luedeman, Clemson University, Clemson, SC 29635

Let S be a semigroup. A nonempty subset Q of S is a quasi-ideal if $QS \cap SQ \subseteq Q$. A nonempty subset B of S is a bi-ideal if $BS^1B \subseteq B$. Let Q(S)(B(S)) be the intersection graph of quasi-ideals (bi-ideals) of S. Necessary and sufficient conditions on S for Q(S) to be complete, chordal, or a tree are given. Analogous questions for B(S) are answered.

(70)

LONG CYCLES IN REVOLVING DOOR GRAPHS

I. J. Dejter, University of Puerto Rico and
J. Quintana Lugo*, University of Puerto Rico

It was conjectured by P. Erdös that the simple graph G_k $(k > 0)$, whose vertices are the subsets of cardinality k or k+1 of the set $\{0,1,..,2k\} \subseteq Z$ and whose adjacency is given by subset inclusion, is hamiltonian. We prove that if the graph G_{k-1} is hamiltonian then there exists a cycle in G_k that includes at least 75% of the vertices of G_k. We have also other results in the direction of attacking recursively the above conjecture.

(71)

ALL NON-ABELIAN GROUPS OF ORDER 32 ARE SEQUENCEABLE

B. A. Anderson, Arizona State University

A finite group of order n with identity e is sequenceable if the elements of G can be ordered e, a_2, a_3, ..., a_n such that the partial products e, ea_2, ea_2a_3, ..., $ea_2 \cdots a_n$ are distinct and hence also an ordering of all elements of G. There are 44 non-Abelian groups of order 32. A sequencing is exhibited for each of these groups by means of a "hill-climbing" algorithm. It follows from previous work that all 86 non-Abelian groups of order n, $10 \le n \le 32$ are sequenceable. This evidence supports a conjecture of Keedwell that all non-Abelian groups of order ≥ 10 are sequenceable. Sequenceable Abelian groups have been characterized (Gordon 1961) as those Abelian groups with a unique element of order 2.

(72)

The Vertex Independence Sequence of a Graph Is Not Constrained

Yousef Alavi, Western Michigan University,
Paul Erdös, Hungarian Academy of Sciences,
Paresh J. Malde, and Allen J. Schwenk*, Western Michigan University

We consider a sequence of parameters $a_1, a_2, \ldots, a_m$ associated with a graph G. For example, m can be the maximum number of independent vertices in G and each a_i is then the number of independent sets of order i. Sorting this list into nondecreasing order determines a permutation π on the indices so that $a_{\pi(1)} \le a_{\pi(2)} \le \ldots \le a_{\pi(m)}$. We call a sequence constrained if certain permutations π cannot be realized by any graph. It is well known that the edge independence sequence is constrained to be unimodal. The vertex independence sequence was conjectured to be likewise, but we show that, quite the contrary, it is totally unconstrained. That is, every permutation is realized for some graph.

ABSTRACTS OF CONTRIBUTED PAPERS

(73)

A Public-Key Cryptosystem

Based on Higher Order Cellular Automata

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Abstract

A public key cryptosystem basing on higher order cellular automata is given. To break the system needs to solve a non-linear equation system over the ground domain of the cryptosystem. The number of variables of that equation system is the same as the length of the ciphered block. The ground domain of the cryptosystem can be any mathematical group with another binary operation such that the group multiplication and the other operation satisfying the combined distributive law, for example, any mathematical ring.

(74)

VOLTAGE GRAPHS AND HAMILTONICITY

I. J. Dejter*, University of Puerto Rico and
V. Neumann-Lara, Universidad Nacional Autónoma de México

Let Γ be a cyclic group and let K be a voltage graph with group Γ. If both K and its covering graph G are connected then G admits a free Γ-action $\sigma:\Gamma\times G \to G$ associated to the voltage graph structure of K. A necessary and sufficient condition for the existence of a Hamilton cycle for G invariant under σ, or Hamilton σ-cycle, is the existence of a Hamilton cycle for K having total weight equal to a generator of Γ. On the other hand, an arbitrary graph G admitting a free action σ of a cyclic group Γ can be viewed as the covering graph of a voltage graph. This observation provides a method in the search for Hamilton σ-cycles. This method is applied to establish necessary and sufficient conditions for Hamilton σ-cycles and exponential lower bounds for the number of Hamilton σ-cycles for some problems involving chessknight moves and group actions of chessboard rotations and reflection.

(75)

Combinatorially Determined Elementary Divisors,

Richard A. Brualdi, University of Illinois at Chicago and University of Wisconsin at Madison

Let A be an n by n upper triangular matrix. Thus the diagonal entries of A are the eigenvalues of A and the digraph of A, D(A), is acyclic. The elementary divisors of A, equivalently the Jordan canonical form of A, are said to be combinatorially determined provided they depend only on the digraph D(A) and not on the particular values of the nonzero entries of A. The elementary divisors corresponding to a particular eigenvalue are then determined by the k path numbers of the reduced digraph corresponding to the eignvalue. We shall discuss some classes of matrices which have combinatorially determined elementary divisors. We shall also discuss the elementary divisors of the m^{th} compound of a matrices whose digraphs are paths and more generally directed trees.

(76)

On f-Covered Graphs

Guizhen Liu, Simon Fraser University, Cadana v5A 1S6

Abstract

A graph G is f-covered if each edge of G belongs to an f-factor. A necessary and sufficient condition for a graph to be f-covered is given. It is proved that if a graph G is m-covered and n-covered, then G is k-covered where m, n and k are integers with the same parity, $m < k < n$, and an $(r-1)$-edge connected r-regular graph of even order is k-covered for any integer k, $1 \leq k \leq r$.

ABSTRACTS OF CONTRIBUTED PAPERS

(77)

MINIMAL TRELLISES FOR BLOCK CODES

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Basic concepts in the study of decoding trellises for block codes are defined. It is shown that minimal proper trellises exist for all block codes. For linear (n,k,d) codes over $GF(q)$ it is shown that the maximum number of states in the minimal proper trellis is at most q^s where

$$s \geq \min(k, k+2d-n-2).$$

Combined with a previous lower bound of Wolf, this shows that

$$s = \min(k, n-k)$$

for MDS codes.

(78)

K-EDGE-CONNECTED D-CRITICAL GRAPHS OF MINIMUM ORDER

L. Caccetta (Western Australian Institute of Technology)
W. F. Smyth (McMaster University)

An undirected graph of diameter D will be said to be **D-critical** if the addition of any edge decreases D. The properties of D-critical graphs are conveniently discussed in terms of vertex sequences. Here we use the properties of such sequences to describe edge-maximal D-critical K-edge-connected graphs on a minimal vertex set. Unlike similar K-vertex-connected graphs studied by Ore, these (D,K)-graphs have a complex structure which depends heavily on the value of D mod 3. Further application of these methods promises to lead to a complete characterization of edge-maximal (D,K)-graphs of arbitrary order.

(79)

A BIJECTIVE PROOF OF THE MURNAGHAN-NAKAYAMA RULE

Adriano M. Garsia, University of California, San Diego
Michelle L. Wachs*, University of Miami

The Murnaghan-Nakayama rule is a well-known combinatorial algorithm for computing the irreducible characters of the symmetric group. This rule involves a signed counting of rim-hook tableaux. Our point of departure in proving this rule is a combinatorial description of the irreducible representations of the symmetric group as products of matrices. The nonzero diagonal entries of the product matrix correspond to certain standard Young tableaux. We construct a sign reversing involution on these standard tableaux and a sign preserving bijection from the fixed points of the involution to the rim-hook tableaux counted by the Murnaghan-Nakayama rule.

(80)

Bounds on Covering and Independence Numbers for Graphs of Large Girth

R.D. Dutton* and R. C. Brigham, University of Central Florida

The well-known fact that, for girth at least four, nodes sufficiently close to any node induce a tree is used in a straightforward fashion to develop bounds for the node and edge covering and independence numbers, mainly in terms of girth, minimum degree and maximum degree. In spite of the simplicity of derivation, the results represent for some situations an improvement over others known to the authors. Some derivations take advantage of a theorem by Johnson and Perry showing that every graph has an edge for which the sum of the degrees of its end nodes is at least twice the average degree of the graph.

ABSTRACTS OF CONTRIBUTED PAPERS

(81)

Shortcuts for some calculations in systems where squaring is "free"

R.C. Mullin,* I.M. Onyzschuk* and S.A.Vanstone, University of Waterloo
*Current address: California Institute of Technology

In certain systems, such as the fields $GF(2^n)$, it is possible to represent elements so that the operating of squaring can be performed in a trivial fashion. We show that in these circumstances operations such as exponentiation and the calculation of multiplicative inverses can be calculated by "more efficient" algorithms than those known for general modular systems. (Analogous results can be obtained in fields of "small" prime characteristic).

(82)

Hamilton cycle on the strong product of graphs

P. Paulraja, University of Waterloo.

Let $\boxtimes G^k$ be the graph obtained by taking the strong product of G with itself, k times. We estimate a value of k for which $\boxtimes G^k$ is hamiltonian, whenever the vertex set of G can be covered by paths of positive length and $K_{1,3}$. In the special case, our estimated value of k supports the following conjecture of Bermond et. al.

Conjecture: For any connected graph G with at least two vertices $\boxtimes G^{\Delta(G)}$ is hamiltonian.

(83)

Connectivity of Permutation Graphs

Barry L. Piazza U. of Southern Mississippi

For a graph G with vertices labeled 1,2,...,n and a permutation α in S_n, the permutation graph $P_\alpha(G)$ consists of two copies of G, say G_x and G_y, along with the permutation edges $(x_i, y_{\alpha(i)})$, for $1 \leq i \leq n$. The purpose of this paper is to examine the connectivity of permutation graphs. In particular, upper and lower bounds for the connectivity of permutation graphs are found. Also, the connectivity and edge-connectivity are determined for permutation graphs of trees, cycles, wheels, n-cubes, complete graphs, and complete bipartite graphs. Finally, the connectivity of the permutation graph $P_\alpha(G)$ is determined for all α in the automorphism group of the original graph G.

(84)

ON WELL COVERED GRAPHS OF SMALL GIRTH

A. Finbow, B. Hartness - Saint Mary's University, Halifax, Canada and R. Nowakowski - Dalhousie University, Halifax, Canada

A graph is said to be well covered if every maximal independent set of vertices is also maximum (Plummer, 1970). Consider the graph K_2 consisting of a single edge joining 2 vertices, say x and y. A vertex v in a graph G will be called <u>extendable</u> if the graph G′ formed from G and K_2 by joining v to x by an edge is well covered. Besides other results, we show that almost all well covered graphs of girth 5 (or more) have extendable vertices. Then a characterization of such graphs is given. The very limited number of exceptions (girth 5 or more but no extendable vertices) will also be discussed.

ABSTRACTS OF CONTRIBUTED PAPERS

(85)

RETROGRADE COMMA-FREE CODES

Michael E. Mays, West Virginia University

Comma-free codes are so named because the dictionary of codewords is chosen so that overlaps of codewords are excluded from the dictionary. There is no need to include a special symbol to separate codewords because breakpoints are determined from the context.

We consider ways in which results in this area should be modified to be extended to what are called retrograde comma free codes, characterised by the property that not only overlaps but also reversals of overlaps are excluded from the dictionary. Such a code should be used if the message to be decoded might arrive with it unclear whether "left to right" or "right to left" is appropriate. If palindromes are excluded from the dictionary then not only content but direction can be determined.

(87)

Knowledge Based Resource Allocation for Dedicated Multiple Microprocessor Applications

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Multimicroprocessor applications are becoming very important in applications such as robotics, navigation, process control, and others. MML, a development system for this purpose, features a concurrent language, the generation of processor-independent code generators, and the specification of configurations.

A system with explicit representation and utilization of a knowledge base increases the general flexibility and capability of a system of this type. Among the areas in MML or a similar system, where a knowledge base can contribute most, is the resource allocation, the function that attempts to map logical process-oriented description to possible architectural configurations of processors, memories, and i/o channels in order to optimize performance or reliability. Resource allocation is characterized by large solution space, high cost in evaluating partial allocation, and the general lack of algorithms.

To augment the MML system with resource allocation, suitable and relevant knowledge is to be acquired, represented and utilized to facilitate this process. The existing structure of MML is modified to interface with the knowledge based subsystem. This knowledge based subsystem basically consists of a planner and an allocator, with the former, in conjunction with simulation and other tools, laying out the strategies of attack and the latter, performing the details of resource allocation.

(86)

"Hamiltonian Connectivity of the Halin Graphs"

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ABSTRACT

A Halin Graph is a plane graph H = TUC, where T is a plane tree of order at least four with no vertices of degree two, and C is the cycle connecting the endvertices of T in the order determined by the embedding of T. It will be shown that a Halin graph is Hamiltonian-connected.

(88)

Generalized Packings and Coverings of Graph

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R. Allan, University of North Alabama, Florence, AL 35630

For a set of vertices $S \subseteq V(G)$ and $x \in V(G)$, $deg_s x$ is defined to be the number of vertices $y \in S$ adjacent to x. A set $S \subseteq V(G)$ is a degree-packing set of order k, if for each $v \in S$, $deg_s v < k$. A set $S \subseteq V(G)$ is defined to be a degree-covering set of order k, if for every $v \in V(G)$, $deg_s v \geq k$. The degree-packing number of order k, denoted $P_k(G)$ is the maximum cardinality of a degree-packing set of order k, and the degree-covering number of order k, denoted $C_k(G)$, is the minimum cardinality of a degree covering set of order k. This paper deals with these parameters and relates these to similar parameters defined by Meir and Moon, Fink and Jacobson, Hochbaum and Shmoys.

ABSTRACTS OF CONTRIBUTED PAPERS

(89)

Fixed window size decoding of convolutional codes

D. A. Leonard* and C. A. Rodger, Auburn University

Convolutional codes are essentially infinite wordlength cyclic codes. ...d window size decoders such as the Viterbi decoder are recursive ...emes that approximate the most recent T sets of received digits by ...e corresponding digits in a bounded number of codewords in order to make a hard decoding decision.

This paper deals with the correct choice of window size for a given code, the allowable error rate, and a method for dealing with errors that exceed that allowable error rate (in order to avoid infinite error propagation caused by the decoder).

(90)

Finding Hamiltonian Cycles in Ore Graphs

Michael O. Albertson, Smith College

A graph G with V vertices is called an *Ore graph* if for every pair of non adjacent vertices, say u and v, deg(u) + deg(v) >= V. That Ore graphs are Hamiltonian is classic. This paper presents a proof of Ore's theorem that leads to a $O(V^2)$ algorithm to find a Hamiltonian cycle in an Ore graph. This improves the work of Bondy and Chvatal who used Ore's elegant closure operation to drive a cubic algorithm.

(91)

INDEPENDENCE AND UPDATING IN EXPERT SYSTEMS

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The response of automated/computerized assistants in specialized areas -- so-called expert systems -- are governed by rule-based inference systems. These inference systems must permit the degree of confidence in conclusions drawn from previous evidence to be revised by the introduction of new evidence. Non-updating conditions are those under which the probabilities of such inferences are not changed by any new evidence. We show that some of these conditions that have appeared in the literature can be simplified in certain circumstances and that they satisfy several logical relationships.

(92)

The Ascending Subgraph Decomposition Problem

Yousef Alavi, A. J. Boals, Gary Chartrand* and
Ortrud R. Oellermann, Western Michigan University
and Paul Erdös, Hungarian Academy of Sciences

Let G be a graph of positive size q and let n be that positive integer for which $n(n+1)/2 \leq q < (n+1)(n+2)/2$. The graph G is said to have an ascending subgraph decomposition if G can be decomposed into n subgraphs $G_1, G_2, \ldots, G_n$ such that $|E(G_i)| < |E(G_{i+1})|$, $i = 1, 2, \ldots, n-1$, and G_i is (isomorphic to) a subgraph of G_{i+1}. Several classes of graphs possessing an ascending subgraph decomposition are described.

ABSTRACTS OF CONTRIBUTED PAPERS

(93)

de Bruijn Graphs and Sliding Sets

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University of Nebraska - Lincoln
Lincoln, Nebraska

A subset S of the set of vertices of a de Bruijn graph is called a sliding set if for each u in S there is a pair of directed edges (u,v) and (w,u) of the de Bruijn graph such that both v and w belong to S. The concept of a sliding set was introduced by Ph. Piret to study automorphisms of convolutional codes. We analyze the structured of sliding sets in a de Bruijn graph. A natural equivalence relation is defined in the family of sliding sets and an expression for the lengths of orbits is obtained. Some special types of sliding sets are classfied.

(95)

REPRESENTATION OF KNOWLEDGE AS A TWO ENTITY GRAPH

Arthur B. Kahn & John Sigler
University of Baltimore

A graph representation of problem solving knowledge is proposed. The model uses a graph with strict alternation of two node types: Data and Processes. Recursive algorithms for forward as well as backward problem solving are presented. The forwards algorithm is shown to be equivalent to Predicate Calculus Normal Form.

Use of these algorithms for Inference Engines in Expert Systems is discussed and an example is presented. Some features of a machine architecture to facilitate these algorithms are discussed.

(94)

Problems on supereulerian and collapsible graphs.

Paul A. Catlin, Wayne State University, Detroit MI 48202

A graph is supereulerian if it has a spanning closed trail. A graph G is collapsible if for every even set $X \subseteq V(G)$ there is a spanning connected subgraph G' of G, such that the set of vertices of odd degree in G' is X. Let H be a connected subgraph of G. The contraction G/H is obtained from G by contracting H to a single vertex, such that $E(G) - E(H) = E(G/H)$. If H is collapsible, then G is supereulerian (resp., collapsible) if and only if G/H is supereulerian (resp., collapsible). We developed collapsibility as a useful reduction tool for determining whether a given graph is supereulerian. We discuss this topic and pose some questions.

(96)

A Packing Problem for Star Forest

by

R. J. Faudree, A Gyarfas[/], and R. H. Schelp[*]

Memphis State University

Let G be a graph with $\binom{n+1}{2}$ edges. Chartrand and Oellermann conjecture that the edge set of G can be partitioned into n sets generating graphs $G_1, G_2, \ldots, G_n$, such that $|E(G_i)| = i$ and G_i is isomorphic to a subgraph of G_{i+1} for all i, i=1,2,...,i-1. We prove the conjecture holds when G is a star forest, i.e. a union of stars.

[/]This author is on leave from the Hungarian Academy of Sciences Computer and Automation Institute.

ABSTRACTS OF CONTRIBUTED PAPERS

(97)

Resolvable designs with block size 3.

W.D. Wallis, Southern Illinois University - Carbondale.

We give a simple but combinatorially interesting proof of the nonexistence of a resolvable balanced incomplete block design with $v = 6$ and $k = 3$ when $\lambda \equiv 2 \pmod 4$.

(98)

A Computational and Graph Theoretic Approach to Nonassociative Algebras

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Iowa State University and Clemson University

ABSTRACT

A fundamental problem in nonassociative algebra is determining identities valid for various classes of algebras. In this paper we examine several computational approaches to the problem. A family of graphs, called associator graphs, is defined. We show that the Teichmuller-like identities, which are valid in all algebras, can be viewed as linear combinations of cycles in the associator graphs. We next examine the identity problem for the class of right alternative algebras. We show how this problem relates to a special class of associations called basic associations, and we obtain an upper bound on the number of these. Finally, we show how the problem for verifying an identity can be viewed as a special flow problem on the associator graphs.

(99)

ANY FINITE SIMPLE GRAPH OCCURS AS AN INDUCED SUBGRAPH OF SOME STRONGLY REGULAR GRAPH

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The subgraph of $G = (V,E)$ induced by a set $X \subseteq V$ has the usual meaning of the maximal subgraph of G which has X as vertex set. The theorem stated in the title becomes trivial without the word "induced", since strongly regular graphs exist with arbitrarily large cliques. Given a finite simple graph $H = (V',E')$, $|V'| = n$, we constructively prove the existence of a strongly regular graph $G = (V,E)$ and an n-set $X \subseteq V$ which induces a subgraph of G isomorphic to H. In fact we may take G to be of Latin square type with $|V| < n^6$. The bound n^6 can doubtless be improved but we conjecture that the problem of minimizing $|V|$ is NP-complete.

(100)

TRAVERSAL PROBLEMS IN GRAPHS WHOSE EDGES AT EACH STAGE HAVE FIXED LIKELIHOODS OF BEING OPEN FOR TRAVERSAL

DAN PRITIKIN MIAMI UNIVERSITY, OXFORD OH 45056

The edges of a graph G are assigned probabilities via a function $p:E \to [0,1]$. One is to traverse through G as per a specified problem [such as the Shortest Path Problem or Chinese Postman Problem], except that at each stage t, only a subset E_t of the edges are available for traversal. For each e and t, independent random variables determine whether e is to be included or excluded in E_t, the former with probability p(e). Natural optimization problems are defined (requiring plenty work in itself), some algorithms are found for determining optimal strategies and expected traversal times, and some special cases of (G,p) are studied.

ABSTRACTS OF CONTRIBUTED PAPERS

(101)

The Radical of a Hadamard Matrix

Robert L. McFarland, University of Minnesota, Duluth

A Hadamard matrix of order n is an n by n matrix with entries ± 1 that has pairwise orthogonal row vectors. Given a Hadamard matrix H of order n, let H_i $(i = 1, \ldots, n)$ be the Hadamard matrix obtained from H by multiplying the column vectors by ± 1 so that H_i has all 1's in its i-th row. Let M_i $(i = 1, \ldots, n)$ be the module generated by the row vectors of H_i over Z, the ring of integers. We define the radical, $\mathcal{R}(H)$, of H to be the intersection of the Z-modules $M_1, \ldots, M_n$. The radical can also be characterized as the largest submodule of each M_i which is closed under termwise multiplication by the elements of M_i. The radical is isomorphic to the matrix algebra over Z consisting of all integral matrices A for which $H^{-1}AH$ is an integral diagonal matrix. The quotient groups $M_1/\mathcal{R}(H), \ldots, M_n/\mathcal{R}(H)$ of the Z-modules are finite and isomorphic. These quotient groups are trivial if and only if H is equivalent to a Sylvester Hadamard matrix.

(103)

MORE ON AMIDA GRAPHS AND BI-COLORED PATHS

Richard D. Ringeisen, Clemson University

In this paper we continue the investigation of certain bi-colored paths in graphs which arise as generalizations of the ancient oriental choosing game called amida. An earlier paper at this conference introduced the concept of amida paths and demonstrated where and how they arise in various graphs. An elusive question posed in that paper is whether an n-connected graph must have somewhere in it n bicolored paths of the amida type. Unfortunately, this question remains unanswered. Here we indicate the progress which has been made and discuss the relationship to certain other difficult problems such as characterizing n connected graphs all of whose edges are "essential edges" in the sense of Tutte and others.

(102)

The Parallel Complexity of Matching Restricted to Degree Defined Graph Classes

Elias Dahlhaus and Marek Karpinski
University of Bonn

We present an NC^2-algorithm constructing, for each graph, a perfect matching, which has an even number of vertices and whose minimal degree is at least half of the number of vertices. We also will prove that matching restricted to regular graphs of degree 3, 2-connected regular graphs of degree 4, and 2-connected graphs of maximal degree 3 is matching complete by NC^2-reductions.

(104)

Generation of k-combinations from a family of sets

Tom Altman, Dept. of Comp. Sc., University of Kentucky.
Marek Chrobak, Columbia University, (on leave from the University of Warsaw).
Mirek Truszczynski, Dept. of Comp. Sc., University of Kentucky.

Let U denote a set of n distinct elements and let $S_1, S_2, \ldots, S_m$ be subsets of U. We consider algorithms which solve the following problem: List all k-combinations C of U, such that $C \subseteq S_j$, for some $1 \le j \le m$.

The optimal running time algorithm for this problem would generate all such combinations in O(tk) steps, where t is the number of k-combinations. For the so called acyclic families of sets and for families of sets of cardinality O(k), we propose algorithms that are optimal in the above sense (i.e., the actual generation of the k-combinations is carried out in time proportional to the length of the output). We also conjecture that for a family of sets with a fixed depth of intersection d, (for all $u_i \in U$, u_i is a member in at most d of the S_i's), the generation of the k-combinations may be carried out independently of m, the number of subsets.

ABSTRACTS OF CONTRIBUTED PAPERS

(105)

Steiner Quadruple Systems with Spanning Block Design

Hung-Lin Fu, Auburn University, Alabama

A spanning block design of a Steiner quadruple system (Q,q) is a subcollection b of q such that (Q,b) is a block design. It was conjectured by C. C. Lindner that for each $v \equiv 4 \pmod{12}$ we can construct a Steiner quadruple system of order v which contains a spanning block design.

In this paper, we verify this conjecture for $v = 4^k$, k a positive integer. We also give a recursive construction which shows that if an SQS(v) contains a spanning block design, then we can construct an SQS(4v) which contains a spanning block design.

(106)

A New Parallel Algorithm for the Maximal Independent Set Problem.

Mark Goldberg, Thomas Spencer✗

Department of Computer Science
Rensselaer Polytechnic Institute

Abstract.

A new parallel algorithm for the maximal independent set problem *MIS* is constructed. It runs in $O(\log^4 n)$ when implemented on a linear number of EREW-processors. This is the first deterministic algorithm for *MIS* whose running time is polylogarithmic and whose processor-time product is optimal up to a polylogarithmic factor.

(107)

ON THE EDGE-CONNECTIVITY VECTOR OF A GRAPH

Linda M. Lesniak (Drew University) and
Raymond E. Pippert (Indiana-Purdue University at Fort Wayne)

Let G be a graph of order p and let $h = \lfloor p/2 \rfloor$. Then the edge-connectivity vector $\bar{\lambda}(G)$ of G is defined by $\bar{\lambda}(G) = (\lambda_1, \lambda_2, \ldots, \lambda_h)$, where λ_i denotes the minimum number of edges which must be removed in order to separate a set of at least i but not more than h vertices of G from the remaining vertices of G.

Theorem. Let G be a graph with edge-connectivity vector $\bar{\lambda}(G) = (a_1, a_2, \ldots, a_j, n, n, *, *, \ldots, *)$, where $n > 2a_j + 2$. Then $\lambda_i = n$ for $i = j+1, j+2, \ldots, n - a_j$, provided $n - a_j$ is at least $j + 3$.

(108)

ON EFFFICIENT EMBEDDINGS OF COMMUNICATION STRUCTURES

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University of Houston
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A communication structure models the exchange of messages that occurs among the processors of a loosely-coupled system. It can be expressed as a directed graph where nodes correspond to processors and edges represent exchanges between two processors. We define several regular communication structures, namely linear chain, linear ring, k-dimensional array, and k-dimensional torus, and embed them into an n-dimensional hypercube. These embeddings are optimal, i.e. are of minimal cost where cost is defined as the number of intermediate processors through which messages must pass in order to reach their destination.

ABSTRACTS OF CONTRIBUTED PAPERS

(109)

INCIDENCE STRUCTURES WITH REGULAR SETS

J.D. Key, University of Birmingham, U.K.

For a finite incidence structure S with point set Ω and block set B, we look at the action of the automorphism group G of S on the power set $P(\Omega)$ of Ω. If there is a set Δ of points such that G acts regularly on the orbit of Δ in this action, then Δ will be called a regular set for S. This is equivalent to requiring that the set-stabilizer of Δ in G is trivial, or that the orbit of Δ under G has maximal length, $|G|$. We examine some incidence structures, for example finite geometries and designs, to find some condition for the existence of regular sets, and their nature when they do exist.

The notion of regular sets for incidence structures arises naturally in the general determination of the orbit structure of a permutation group on a set Ω, in its natural action on $P(\Omega)$. The existence of regular sets indicates that this representation will contain the regular representation. Counting arguments, together with bounds on the size of finite primitive groups, show that only a finite number of finite primitive groups not containing the alternating group of the same degree, can have the property of having no regular sets. We go some way towards establishing this finite list.

(110)

A Constructive Initial Assignment Algorithm for Mapping Parallel Gaussian Elimination Processes to a Hypercube Multiprocessor

Michael R. Leuze & Stephen R. Schach
Vanderbilt University

The placement of a set of related processes in a multiprocessor system so as to minimize communication overhead is an important problem of parallel computation. In this paper, a constructive initial assignment algorithm is compared with several iterative assignment improvement techniques for parallel Gaussian elimination processes mapped to a multiprocessor system whose interconnection network is a binary n-cube. The various approaches are compared using a hypercube multiprocessor model.

(111)

ON MINIMUM SIZE EDGE CUTS ACHIEVING RESTRICTED COMPONENT ORDER

K.S. Bagga, L.W. Beineke, M.J. Lipman, R.E. Pippert*,
Indiana University-Purdue University at Fort Wayne
and Linda Lesniak, Drew University

Investigation of the edge-integrity of a graph G(p,q) leads to the definition of the separation vector $\eta(G) = (\eta_1, \eta_2, \ldots, \eta_{p-1})$, where η_k is the minimum numbe of edges whose removal leaves each component having order at most p - k. The separation vector is investigated for various classes of graphs, including complete graphs, complete bipartite graphs, and hypercubes.

(112)

Generalized Radon Theorems in Convex Structures

William R. Hare*(Clemson University)
Gerald Thompson (Augusta College)

Radon (1921) proved that any set of d+2 points in R^d can be partitioned into two sets with overlapping convex hulls. With "convex hull" relative to the subfamily consisting of all $A_1 x \ldots x A_d$, where each A_i is convex in R, Eckhoff (1968) proved that any set of $r_2(d)$ points can be 2-partitioned with overlapping "convex hulls," where $r_2(d)$ is the smallest integer r for which

$$\binom{r+2}{\lfloor \frac{r+2}{2} \rfloor} > 2d .$$

Tverberg (1966) showed that every set of (j-1)(d+1)+1 points can be j-partitioned into sets with overlapping convex hulls. Here we look at the analogous problem when "convex hull" has the second meaning. Theorem. Every 2j-set in R^2 can be j-partitioned into sets whose convex hulls (2nd sense) overlap. In R^3 every set of 7 points has a 3-partition and every set of 9 points has a 4-partition, where in each case the "convex hulls" overlap. These numbers are best possible.

ABSTRACTS OF CONTRIBUTED PAPERS

(113)

A LEMMA ON CIRCULAR PERMUTATIONS WITH DISTINCT DIFFERENCES

Herbert Taylor, University of Southern California, Los Angeles

Put symbols $a_1, a_2, \ldots, a_k$ on the vertices on n-1 directed n-gons in such a way that each symbol appears exactly once on each n-gon, and each pair of symbols occurs once in some n-gon at each of the n-1 possible directed distances.

Lemma. For K=3 and K=4, and each circular order ($\Pi a_1, \Pi a_2, \ldots, \Pi a_k$), the number of n-gons with the symbols in that order clockwise must be equal to the number of n-gons with the symbols in that order counter clockwise.

A counter example found by TUVI ETZION shows that the LEMMA fails when K=5.

(114)

A Parallel Implementation for the Domination Number of a Grid Graph

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Clemson University, Clemson, SC 29634

Abstract

Several polynomial algorithms for computing the domination number for various classes of graphs have appeared recently [1,2,4]. The problem of determining the domination number of an arbitary grid graph has recently been shown to be NP-complete[3,4]. In this paper we present a parallel implementation of a linear algorithm for the domination number of a complete K x N grid graph. This algorithm is exponential in K and linear in N for a K x N grid. Algorithms for sequential computers have been implemented at Clemson University[2] and results for K ≤ 8 have been obtained. To get results for larger values of K we designed and implemented a parallel algorithm for a hypercube, a Floating Point Systems T-20[5]. We present our results and discuss some of the implementation issues related to using parallelism to solve problems such as this.

(115)

On the ℓ-Connectivity Function of a Graph

Ortrud R. Oellermann, Western Michigan University

For $\ell \geq 2$, the ℓ-connectivity $\kappa_\ell(G)$ (ℓ-edge-connectivity $\lambda_\ell(G)$) of a graph G is defined as the minimum number of vertices (edges) that are required to be deleted from G to produce a graph with at least ℓ components or with fewer than ℓ vertices. For every $k \in \{0, 1, \ldots, \kappa_\ell(G)\}$, let s_k be the minimum ℓ-edge-connectivity among all subgraphs obtained by removing k vertices from G. The ℓ-connectivity function f_ℓ of G is defined by $f_\ell(k) = s_k$ for $0 \leq k \leq \kappa_\ell(G)$. Some necessary conditions for a function to be the ℓ-connectivity function of a graph are presented.

(116)

Labeling Prisms and Prism Related Graphs

Joseph A. Gallian, University of Minnesota, Duluth

A connected graph with v vertices and $e \geq v-1$ edges is called *graceful* if it is possible to label the vertices x with distinct integers $f(x)$ from $0, 1, \ldots, e$ in such a way that, when each edge xy is labeled with $|f(x) - f(y)|$, the resulting edge labels are distinct. As an additive analog, Graham and Sloane defined a *harmonious* graph as a connected graph with v vertices and $e \geq v$ edges if it is possible to label the vertices x with distinct elements $f(x)$ of Z_e (the group of integers modulo e) in such a way that, when each edge xy is labeled with $f(x) + f(y)$ modulo e, the resulting edge labels are distinct.

We show that all prisms, edge-deleted prisms and vertex-deleted prisms are graceful and harmonious with the single exception that the cube is not harmonious.

ABSTRACTS OF CONTRIBUTED PAPERS

(117)

ON LATIN SQUARES

E. T. Parker, University of Illinois, 1409 W. Green, Urbana, IL 61801

It is conjectured (Brualdi, Stein) that any latin square has a partial transversal only 1 cell deficient: near-transversal (NT); much less has been proved. Evidence is accumulated by computer for: Every latin square has a NT avoiding a pre-assigned row; every latin square has a NT through a given cell. It is natural to conjecture that a NT must exist missing a pre-assigned row and column; there is a size-6 counterexample. To this author's knowledge, bi-transversal (BT) is his invention: 2 cells in each row, 2 in each column, 2 with each symbol. Computer work suggests that each latin square (size 1 discarded as usual as degenerate) has a BT through each cell. A rather general theorem is proved yielding a family of latin squares lacking transversal; three more examples are given not covered by the theorem and perhaps genuinely sporadic. Euler gave an example of two latin 6-squares orthoganal except for a 2-subsquare in each coincident in position--"hole" in the jargon of some. The author gives the only other example. The author thanks warmly University of Illinois students Reid C. Huntsinger, Troye D. Kauffman, Youngwhan Lee, Hyo Yang No and Cameron C. Smith for valuable programming support.

(118)

Efficient computation of the orbit representatives of q-shuffles

Roy J. Fuller, University of Arkansas, Fayetteville

The q-shuffle, an operation which rearranges ordered sets of n elements, is of significance in fast Fourier transform computations and other processes that are adaptable to parallel computation. As a permutation, the shuffle corresponds to multiplication by q in the ring Z_{n-1}, where q does not divide n-1. To fully exploit q-shuffles, one wishes to determine a set of orbit representatives, so that distinct orbits can be rearranged simultaneously. The problem of identifying a representative from each orbit is finite; the only issue is how to do it efficiently. Our solution is to factorize n-1 and exploit a method which rapidly finds a primitive root modulo p^k for odd p. After a O(log n) preliminary computation, the orbit representatives are determined explicitly using a small number of multiplications; theoretical and emperical estimates are provided. A (sequential) computer program uses the method to determine representatives for any n less than 32,768.

(119)

ON CONTRACTIBLE EDGES IN 3-CONNECTED GRAPHS

NATHANIEL DEAN, VANDERBILT UNIVERSITY, ROBERT L. HEMMINGER, VANDERBILT UNIV.
BJARNE TOFT, ODENSE UNIVERSTET

An edge e of a 3-connected graph G is <u>contractible</u> if the graph obtained from G by contracting the edge e is also 3-connected. The main result of this paper is that every longest cycle in a 3-connected graph on at least five vertices contains at least two contractible edges.

(120)

A GRAPH THEORETIC APPROACH TO PROTOCOL TESTING

Anton T. Dahbura* (AT&T Bell Labs-Murray Hill, NJ)

The growing importance and complexity of digital communications networks has made important the problem of testing the various interacting components of such networks to ensure that they conform to their specifications. We show how the concept of UNIQUE INPUT/OUTPUT SEQUENCES, together with graph theoretic optimization techniques, can be successfully used to test communications protocols.

ABSTRACTS OF CONTRIBUTED PAPERS

SOFTWARE SESSION

BEGINS

IN FAU ROOM "A"

(123)

HYPERCUBES ARE SEMIHAMILTONIAN CONNECTED

F.Harary, NMSU and M.Lewinter, SUNY Purchase

A 2-colorable graph is called semihamiltonian connected if for any pair of nodes x,y of opposite color, there exists an x-y hamiltonian path. Such a graph is hamiltonian, but it clearly need not be hamiltonian connected, as C_4 shows.

The hypercube Q_n is recursively defined as follows: $Q_1 = K_2$ and $Q_{n+1} = Q_n \times K_2$. Hypercubes are 2-colorable and we show they are semihamiltonian connected. More generally, if G is semihamiltonian connected, then so is $G \times K_2$. We present several consequences.

(122)

Lexicographically ordered subset sums

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Let $\{a_1 < a_2 < .... < a_n\}$ be a set of n integers whose subsets have all distinct sums. Clearly, $a_i = 2^{i-1}$ provides an example of such a set. Erdös asked how large the maximum element a_n of such a set must be. Conway and Guy have an example where a_n is less than 2^{n-2} and Lunnon has slightly improved their example. We consider a much more tractable question by imposing the condition that the subset sums are increasing when the subsets are ordered first by size and for each fixed size are ordered lexicographically. We give optimal sets under this condition. We also consider the condition that, for some fixed k, the k-subset sums be lexicographically ordered and produce optimal sets. The lexicographic order on the subsets allows the summands to be readily calculated if only their sum is given; such a set is therefore an easy instance of the knapsack problem.

(124)

Graphs of diameter 2

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Using hypergraphtheoretical results (fractional matching and cover, ν-critical hypergraphs) due to Tutte, Erdös, Lovász and others we prove theorems in extremal graphtheory. E.g.

<u>Theorem</u> 1 If $K_n = G_1 \cup \ldots \cup G_t$ is an (edge)decomposition of the complete graph into factors of diameter 2 then (for $n > 800$) $n \geq 6t$.

This problem was investigated by several authors (e.g. Bosák, Erdös, Sauer, Bollobás, Spencer.) Znám proved Theorem 1 for $n > 10^{17}$.

ABSTRACTS
OF CONTRIBUTED PAPERS

(125)

A brief survey of computational group theory

Clifton E. Ealy, Northern Michigan University

In this paper, I survey computational group theory. In particular I will focus on the issues of verification, time complexity, implementation, and portability. The main example I will discuss will be the group theory language cayley.

PLEASE NOTE: SESSION BEGINS AT 2:30 PM.

(126)

Chromatic Polynomials of Chordal Graphs

N. Chandrasekharan and R. Laskar*, Mathematical Sciences Department, Clemson University
C. E. Veni Madhavan, Department of Computer Science and Automation, Indian Institute of Sciences.

We study the chromatic polynomials of the various classes of graphs in the chordal hierarchy. It is known that the chromatic polynomial of a chordal graph G, P(G, t), has the form

$P(G, t) = t(t-1)^{j_1}(t-2)^{j_2} \dots (t-q+1)^{j_{q-1}}$ where q is the clique number of G, and j_i, i = 1, 2, ..., n

are integers greater than or equal to 1. The chromatic class of a class of graphs G is defined as $C(\mathcal{G}, t) = \{P(G, t) : G \in \mathcal{G}\}$. Further, two classes are chromatically equivalent if their chromatic classes are the same. We show the following:

1) Chordal graphs are chromatically equivalent to the threshold and unit interval graphs. This has the implication that the chordal graphs, split graphs, strongly chordal graphs, threshold graphs, undirected/directed path graphs, and interval graphs are chromatically equivalent.

2) For block gaphs the indices j_i's in P(G, t) are nonincreasing.

(127)

OPTIMAL ELEMENTS FOR GENERALIZED WEAK ORDERS

John J. Long, Jr. and Carl Wagner*, University of Tennessee

Let X be an n-set and R a generalized weak order (in the sense of Fishburn) on X. An alternative $x \in X$ is optimal for R if, $\forall y \in X, yRx \Rightarrow xRy$. We determine the limiting distributions and moments, as $n \to \infty$, of random variables which record the number of optimal elements for randomly selected generalized weak orders of several types.

(128)

How Do You Decompose a Graph into Trees of Small Diameter?

Nathaniel Dean, Vanderbilt University, Nashville, TN 37235

It is shown how to decompose an arbitrary graph G into double stars (trees of diameter at most three) and stars (trees of diameter at most two) where the allowed types and numbers of trees used in the decomposition depends on the minimum degree of G and the size of a given maximal matching in G. This method generalizes a theorem (formerly a conjecture by Kotzig) on (2k+1)-regular graphs with a perfect matching.

ABSTRACTS OF CONTRIBUTED PAPERS

(129)

SEDS -- AN EXPERIMENTAL DISTRIBUTED SYSTEM

James Abello and Jing Wang
University of California, Santa Barbara

We present the main elements of a Simple Experimental Distributed, memory, message passing multi-unit System, SEDS, whose logical organization is modeled by a directed multiple linked hypergraph.

One virtue of the proposed system is that, virtually, any unit inter-connection topology can be implemented in a dynamical manner, making SEDS a suitable test bed for experimentation with parallel algorithms intended for many different types of distributed memory, message passing multi-processors.

SEDS is particularly appropriate, as a framework, to be used in software environments whose computations must rely on a series of privately owned and previously defined modules or functions, hardware or software, which are supported by several underlined networks of not necessarily compatible machines.

(130)

LINEAR TIME OPTIMUM RESOURCE ALLOCATION ALGORITHMS FOR TREES

S. T. Hedetniemi, Clemson University and
T. V. Wimer, Clarion University

Let each of the vertices $v_1, v_2, \ldots, v_n$ of a graph $G = (V,E)$ have an associated non-negative integer, called a resource requirement, $r_1, r_2, \ldots, r_n$. Consider the problem of defining a resource assignment $A : V \rightarrow Z$ of integers to the vertices of G which satisfies:

(i) $\sum A(u) \geq r_v$, for every v in V, u in N[v], and

(ii) $\sum A(u)$ is a minimum, u in V.

If we let $r_v = 1$ and we assume that A(v) in {0,1} for every v in V, then the resource allocation problem reduces to the problem of finding the domination number of G. As such this problem is immediately NP-hard. In this paper we discuss a number of variations and generalizations of this problem and we discuss the feasibility of using either of two distinct methodologies for designing linear algorithms for solving problems of this type when restricted to trees or tree-like graphs. In particular, we present a linear algorithm for solving this basic problem for trees.

(131)

ALGEBRAIC STRUCTURES ON INTERSECTION SETS

L. Kirk Tolman - B.Y.U.

An intersection set, II, is a subset of the power set of some set S uch that any two elements of II have non-empty intersection. In our con- ideration, $|S| < \infty$ and II is maximal. Operations are defined which allow ransformation from any one intersection set to any other (same S). This llows a distance function and partial ordering on the collection of all ntersection sets (fixed S). The structure admits a meet but not a join ence is not a lattice. The concept of a basis for an intersection set is lso introduced. Related and consequent problems are discussed.

(132)

Decompositions of Graphs into Trees.

Zbigniew Lonc, George Mason University and Warsaw Technical University

Let Θ be a family of graphs. By a Θ-decomposition of a graph G we mean a partition π of the edge set of G such that every $F \in \pi$ spans in G a subgraph isomorphic to a graph in Θ.

In the talk we state the following conjecture: If T_1 and T_2 are two trees having relatively prime sizes then there exists $c = c(T_1,T_2)$ such that every graph G satisfying the condition $\delta(G) \geq c$ has a $\{T_1,T_2\}$-decomposition. We prove this conjecture for some special pairs of trees. In particular, we prove it in the following cases:

(a) T_1 and T_2 are stars having relatively prime sizes,
(b) T_1 and T_2 are paths having relatively prime sizes and
(c) $T_1 = T_2 - e$, where e is a "pendant" edge in T_2.

ABSTRACTS OF CONTRIBUTED PAPERS

(133)

OBTAINING PROVABLY GOOD SOLUTIONS TO TRAVELLING SALESMAN PROBLEMS

S.C. Boyd, W.R. Pulleyblank, G. Cornuéjols

Suppose that a salesman wants to visit each member of a set of cities once and only once and minimize the total distance travelled. This problem, the so called Travelling Salesman Problem, is well known to be NP-hard in general, but still must be solved in many "real world" situations.

We describe a micro-computer based system which is designed to produce provably good solutions for travelling salesman problems. The system features animated graphic displays of many tour construction and tour improvement methods, as well as bounding procedures. The success and failure of these various methods will be discussed.

PLEASE NOTE: SESSION BEGINS AT 3:30 PM.

(134)

A linear-time algorithm for finding the maximum cardinality of a minimal edge cover on partial k-chordal graphs.

S. T. Hedetniemi, Clemson University, Clemson SC 29630
H. A. Pellerin, Clemson University, Clemson SC 29630
T. V. Wimer, Clarion University of Pennsylvania, Clarion PA 16214

A number of researchers have independently determined that a variety of NP-complete problems admit linear-time algorithms when restricted to the family of partial k-chordal graphs. (See for example, Arnborg and Proskurowski [1]; Robertson and Seymour [2]; Seese [3]; Wimer, Hedetniemi and Laskar [5]; and Wimer [6].) In this paper we generalize a Theorem of Wong, Bern and Lawler [7] and illustrate its application by transforming a recurrence system for solving the edge cover problem on partial k-chordal graphs to a recurrence system for solving the maximum minimal edge cover problem on partial k-chordal graphs.

(135)

On a Problem of Sands Concerning Chains of Subsets

Jerrold R. Griggs
University of South Carolina

In joint work with Charles Grinstead (Swarthmore College) and Roger K.-C. Yeh (South Carolina) a problem posed by Bill Sands is resolved: We prove that the Boolean lattice of all subsets of an n-set can be partitioned into chains of size four if and only if $n \geq 9$. We make a general conjecture specifying the collections of sizes for which there exists a partition of the Boolean lattice into chains of the given sizes.

(136)

Results and conjectures on decompositions of graphs into forests with bounded maximum degree

Miroslaw Truszczynski, University of Kentucky

A *forest decomposition* of a (multi)graph G is a family of edge disjoint subforests of G whose edge-sets cover all edges of G. The minimum number of forests in a forest decomposition of G is called the *arboricity* of G and is denoted by T(G). The well-known result of Nash-Williams states that $T(G) = \max \lceil \frac{|E(H)|}{|V(H)|-1} \rceil$, where maximum is taken over all induced subgraphs H of G with at least two vertices. A natural question arises: how does the Nash-Williams formula change if forests in decompositions have to have maximum degrees bounded by a given integer d. The minimum number of such forests necessary to decompose G will be denoted by $T_d(G)$. In the paper we propose and study the folowing conjecture: for every graph G and for every $d \geq 2$,

$$T_d(G) = \begin{cases} \frac{\Delta(G)}{d} \text{ or } \frac{\Delta(G)}{d}+1 & \text{if } T(G)=\frac{\Delta(G)}{d} \\ \max\{T(G), \lceil \frac{\Delta(G)}{d} \rceil\} & \text{otherwise.} \end{cases}$$

We show that the conjecture is true in the case when $d \geq \Delta(G)+1-T(G)$ and also for complete multigraphs $K_n^{(\lambda)}$ and complete bipartite multigraphs $K_{m,n}^{(\lambda)}$. In the case when d=2 and G is regular our conjecture reduces to $T_2(G)=T(G)$ and generalizes the Linear Arboricity Conjecture ($T_2(G)$ is the linear arboricity of G). For this case we prove that if G is a Δ-regular multigraph and Δ=2,3,4 and 6, then the conjecture holds, i.e., $T_2(G)=T(G)$.

ABSTRACTS OF CONTRIBUTED PAPERS

(137)

ON THE ENUMERATION OF ONE-FACTORIZATIONS OF COMPLETE GRAPHS CONTAINING PRESCRIBED AUTOMORPHISM GROUPS

E. Seah and D. R. Stinson, Department of Computer Science, University of Manitoba

A one-factorization (OF) of a complete graph K_{2n} is a partition of the edge-set of K_{2n} into 2n - 1 one-factors, each of which contains n edges that partition the vertex-set of K_{2n}. A perfect OF is an OF in which every pair of distinct one-factors forms a Hamiltonian cycle of the graph.

In this paper, we use orderly algorithms to enumerate (perfect) one-factorizations of complete graphs, the automorphism groups of which contain certain prescribed subgroups. We showed that, for the complete graph K_{12}, excluding those one-factorizations containing exactly one automorphism of six disjoint cycles of length two, there are precisely 56391 non-isomorphic one-factorizations of K_{12} with non-trivial automorphism groups. We also determined that there are precisely 21 perfect one-factorizations of K_{14} that contain non-trivial automorphism groups.

(139)

A Hamilton Path in the Rotation Lattice of Binary Trees

D. Roelants van Baronaigien & F. Ruskey, University of Victoria

The *rotation graph*, G_n, has vertex set consisting of all extended binary trees with n internal nodes. Two vertices are connected by an edge if a single rotation will tranform one tree into the other. We provide a simpler proof of a result of Lucas (1986) that G_n contains a Hamilton path. Our algorithm is based upon a different sequence representation of the tree. Furthermore, we provide a simple constant average time algorithm for generating the trees along the Hamilton path. Other published algorithms for "generating binary trees" generate some sequence representation of the trees. Our algorithm produces the trees in the more customary left and right pointer representation via rotations.

(138)

The k-processing center of a graph

Dana G. Cikanek* and Peter J. Slater
Department of Mathematics and Statistics
University of Alabama in Huntsville
Huntsville, AL 35899

We define a multiprocessor job scheduling problem in which the following describes the case when each of the jobs requires the same amount of time. Call subset S of vertex set V(G) k-processable in G if (1) $|S| \leq k$, (2) G - S is connected, and (3) S is independent. Write $PC_k(v) \leq t$ if there are subsets S(1), S(2), ..., S(t) of V(G) with $v \in S(t)$ and S(j) is k-processable in $G-(S(1) \cup S(2) \cup \ldots \cup S(j-1))$ for $1 \leq j \leq t$. Write $PC_k(v)=t$ if t is the minimum value for which $PC_k(v) \leq t$.

Determining if $PC_k(v) \leq 3$ is NP-complete, even for planar graphs. Letting $PC_k(G)$ be the set of vertices, v, for which $PC_k(v)$ is a maximum, for a tree T we have $PC_1(T)$ is the median and $PC_k(T)$ is the center for k large. We discuss in detail the structure for $PC_k(T)$.

(140)

Near 2-factorizations of $2K_n$

James Burling, SUNY, Oswego
Katherine Heinrich*, SFU, Burnaby

Hanani has shown that $2K_n$, $n \equiv 1 \pmod 3$, can be decomposed into factors, each consisting of (n-1)/3 triangles and an isolated vertex. We show first that when $n \equiv 1 \pmod 4$ $2K_n$ can be decomposed into factors each of which consists of (n-1)/4 four-cycles and an isolated vertex. (In fact when $n \equiv 1 \pmod{4t}$ a similar argument shows that the analagous result holds for cycles of length 4t.) Secondly, we consider the question of rotational solutions.
This problem is one of the possible variants of the Oberwolfach problem.

ABSTRACTS OF CONTRIBUTED PAPERS

(141)

Comparison of two algorithms solving a version of the "ham-sandwich" problem.

P. Gburzynski - University of Alberta, J.W.Jaromczyk -University of Kentucky

This paper describes issues of the implementation and the asymptotic running time performance of two different algorithms solving a 3-dimensional version of the "ham-sandwich" problem (simultaneous four-section of two point sets in 3-dimensional space). The first algorithm is a generalization of Willard's algorithm for 2-dimensional version of the problem. The second one is based on a reduction of the considered problem to 2 dimensional linear programming; then the famous Megiddo/Dyer linear worst-case time algorithm is employed.
The running time performance of both algorithms is analyzed on various distributions of the input data.

PLEASE NOTE: SESSION BEGINS AT 4:30 PM.

(143)

Solution of some Multi-Dimensional Lattice Path Parity Difference Recurrence Relations using Involutions

Frank Ruskey, Department of Computer Science, University of Victoria

Many elementary combinatorial objects can be modeled as restricted multiset permutations. Standard examples include (unrestricted) permutations of a multiset and ordered trees with prescribed degree sequence. In developing algorithms to generate all members of a subset S of multiset permutations in such a way that successive permutations differ only by the interchange of adjacent distinct elements, we are led to the *adjacent interchange graph*, $G(S)$, of S. The vertices of $G(S)$ are the elements of S and two vertices are connected by an edge if one can be obtained from the other by an adjacent interchange. This graph is bipartite. No adjacent interchange algorithm is possible if the number of vertices in the two bipartitions differs by more than one. There is a simple recurrence relation that describes the difference of the number of vertices in the two bipartitions. These recurrences were solved for the examples mentioned above by Ko and Ruskey (1986) using induction. Here we solve special cases of those recurrences by means of involutions. These new proofs shed more light on the nature of the solutions.

(142)

AN EVEN FASTER APPROXIMATION ALGORITHM FOR THE STEINER TREE PROBLEM IN GRAPHS

L.T. KOU
K. MAKKI

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Computer Science Division
University of California, Davis
Davis, California 95616

ABSTRACT

In this paper we consider the Steiner problem in graphs, which is the problem of connecting, at minimum total distance, a set of vertices in a connected undirected distance graph. For this problem we develop an $O(|E|+|V-S|\log|V-S|+n\log\beta(n,|S|))$ approximation algorithm, where V is the set of vertices, $S\subseteq V$ is the set of Steiner vertices, E is the set of edges in the graph, $n=\min(|E|,|S|(|S|-12)$ and $\beta(n,|S|)=\min\{i|\log^{i}\leq n/|S|\}$. The ratio of the total distance on all the edges of a Steiner tree generated by the algorithm to that of the optimal tree is not greater than $2(1-1/L)$, where L represents the number of leaves in the optimal tree.

(144)

On (n,k)-coloring of complete graphs.

A. Gyárfás
Memphis State University - Hungarian Academy of Sciences

An (n,k)-coloring of a complete graph K means a coloring of the edges of K with k colors so that all monochromatic connected subgraphs have at most n vertices. An (n,k)-coloring can be viewed as k partitions of a ground set into sets of cardinality at most n such that all pairs of elements appear together in some of the sets. Resolvable block designs with k parallel classes and with blocks of size n are natural examples of (n,k)-colorings. However, (n,k)-colorings are much more "relaxed" structures since the blocks may have any sizes up to n, moreover the pairs of the ground set may appear together in many blocks.

The talk surveys results concerning the maximum number of vertices of a complete graph with (n,k)-colorings.

ABSTRACTS OF CONTRIBUTED PAPERS

SOFTWARE SESSION

CONTINUES

IN FAU ROOM "A"

(146)

Application of Graph models and their derivatives in Universities and Industries*

G.S. Hura
Dept. of Computer Science
Wright State University
Dayton, Ohio

Abstract

Over the last two decades, Petri nets and related graph models have emerged as very useful and powerful modeling tool for the representation and analysis of computer systems, particularly ones exhibiting concurrency. It is an abstract model and uses the notion of conditions and events. It is a bipartitle directed graph and consists of two types of nodes, namely places and transitions. The dynamic behaviour of any system can be modeled at any level of abstractions and also can be simulated to study the dynamic properties. These models have been used in a variety of applications, like communication protocols, events and conditions, computer hardware and software. Last couple of years has seen a great interest among the researchers to use the notion of time with Petri net and use the nets for the performance evaluation of systems. The derivatives or arguments of Petri nets so obtained are times Petri nets, stochastic and generalized stochastic Petri nets. This paper will in brief discuss the definitions and notations of these graph models and also how the researchers engaged in Universitits and industries are using them in various applications.

(147)

Equivalence Relations For Posets and Interval Representations.
John Gimbel,* Colby College, Waterville, Maine and Carsten Thomassen, Mathematics Institute, DTH, Copenhagen, Denmark.

Given a poset P=(V,E) a directed partitive set is a subset S of V with the property that any vertex of V not in S is adjacent (1) with no vertices in S; (2) from all vertices in S or (3) to all vertices in S. Given a poset, if we reverse the orientation on all arcs with both endpoints in some partitive set a new poset will be formed. We shall see that given two posets which have the same underlying graph,one can be formed from the other by a sequence of such reversals. In addition, we provide a simple method for obtaining any interval representation from any other representation of the same interval graph.

(148)

A degree sequence condition for Class 1 multigraphs.

A. G. Chetwynd (University of Lancaster), and

A. J. W. Hilton (University of Reading, visiting Auburn University)

We give a degree sequence condition for a Class 1 multigraph. We also discuss some related problems on degree sequences.

ABSTRACTS OF CONTRIBUTED PAPERS

(149)

On Computer Generated Problems and Exercises

Siemion Fajtlowicz, University of Houston

The purpose of this talk is to discuss several new conjectures of the computer program Graffiti to which I do not know the answers; to present a few solutions and partial solutions to some of Graffiti's other conjectures; and to discuss conjectures of Graffiti which I use in my graduate class in Graph Theory as exercises.

I will also discuss some methods employed in removing non-interesting conjectures and other problems arising in writing the program.

(150)

P_4-Trees

Jeremy Spinrad, Dept. of Computer Science, Vanderbilt U.

This paper introduces a new data structure for dealing with graphs, which will be called a P_4-tree. The P_4-tree is a generalization of a cotree, which has been used to design efficient algorithms for graphs which do not contain an induced P_4. A linear time algorithm for constructing a P_4-tree will be described. P_4-trees can be used as part of an efficient algorithm for determining whether a graph contains any nontrivial modules.

(151)

A Bound on the Order of a Finite Projective Plane

C. Y. Ho

Department of Mathematics
University of Florida
Gainesville, Florida 32611

ABSTRACT. If a finite projective plane admits a collineation group G, then the order of the plane is bounded by a function of $|G|$ and the number of the regular G-orbits of points.

Also the following result is proved. If a finite projective plane admits A_5 as a collineation group without any regular point orbits, then the plane is Desarguesian of order 4, 5, 9 or 11.

(152)

Uniqueness of impartial edge-colourings

by M. N. Ellingham (Vanderbilt University) and Y. Caro (Tel Aviv University)

A *(proper) k-edge-colouring* of a multigraph assigns one of k colours to each edge, so that no two edges of the same colour are adjacent. Such a colouring is *impartial* if the numbers of edges of any two colours differ by at most 1. In 1978 A. G. Thomason showed that for $k \geq 4$, no graph with more than k edges has a unique k-edge-colouring. By using his result, we show here that for $k \geq 4$, no graph with more than k edges has a unique *impartial* k-edge-colouring. As a corollary, any graph with more than k edges which has a decomposition into k matchings of equal size has at least two such decompositions when $k \geq 4$.

ABSTRACTS OF CONTRIBUTED PAPERS

(153)

Non-Existence of Several Small Abelian Difference Sets

D. de Caen, Queen's University, Kingston, Ontario

We show the non-existence of some (v,k,λ)-difference sets in certain abelian groups. For example, we show the non-existence of a $(27,13,6)$-difference set in $Z_3 \times Z_9$, and of a $(375,34,3)$-difference set in $Z_3 \times Z_5 \times Z_{25}$. The argument uses known multiplier theorems, in addition to a simple counting argument that restricts the distribution of values in each coordinate of the members of a hypothetical difference set.

(154)

A LINEAR ALGORITHM FOR COMPUTING THE KNIGHT'S COVERING NUMBER OF A KXN CHESSBOARD

E. O. Hare,[†] S. T. Hedetniemi
Department of Computer Science
Clemson University, Clemson, SC 29634

We say that a chessboard is covered by the placement of a set H of knights on the squares of the board if every square is either occupied by a knight or can be occupied in one move by a knight from H. We present an algorithm for determining the minimum number of knights needed to cover a KxN chessboard. This algorithm is linear in N, for any fixed K, but is exponential in K. Some computational results are given.

(155)

Symmetry Groups of Perfect One factorizations of K_{2n}

Edwin Ihrig
Department of Mathematics
Arizona State University
Tempe, Arizona
85287

We give some fairly sharp results characterizing the structure of the symmetry group of a perfect one factorization of the complete graph. Since most of the existing algorithms designed to generate perfect one factorizations are consequences of natural assumptions about the symmetry group of the one factorization, these results cast considerable light on the successes and failures of these algorithms. Also we give some natural new algorithms which are determined by symmetry assumptions compatible with these results.

(156)

Sparse Matchings in The Johnson Graph J(n,k)

Joseph Hemmeter, University of Delaware
Yiming Hong*, Wright State University

A set (subset) is an i-set (i-subset) if its cardinality is i. The Johnson graph J(n,k) is the undirected graph whose vertex set V is the family of the k-subsets of an n-set X and whose adjacency is defined by that, for any v_1 and v_2 in V, v_1 and v_2 are adjacent if and only if $|v_1 \cap v_2| = k-1$. A sparse matching S of a simple graph G is a collection of edges of G such that the distance between any two edges in S is at least 2. Let M(n,k) be the maximum number of edges that a sparse matching in J(n,k) can have. Then by a counting argument it can be shown that

$M(n,k) \le C(n,k-1)/(2k-1)$ where C(n,k-1) is the binomial coefficient.

One can easily see that

$M(n,2) = [n/3]$, the greatest integer $\le n/3$.

In the case when k = 3, we have the following result :

$M(n,3) = C(n,2)/5$ if $n \equiv 1 \pmod 5$.

By a result of Richard M. Wilson (Decomposition of complete graphs into ···), we also have:

$M(n,3) = C(n,2)/5$ if $n \equiv 0$ or $1 \pmod 5$ and if n is sufficiently large.

In the other cases, we obtain partial results including some examples where the bounds are not met.

The notion of sparse matchings can be also generalized by requiring that the distance between edges in such a matching is at least t, where t is an integer ≥ 2.

ABSTRACTS OF CONTRIBUTED PAPERS

(157)

METHODS FOR THE STRUCTURAL ANALYSIS OF TENSORS

John S. Maybee
University of Colorado

We consider multiply subscripted arrays and develop several combinatorial tools for studying the structure of them. If the array A has p subscripts, $p \geq 2$, then we associate with A in a natural way a p-partite graph G. It turns out that G is also a simplicial complex composed of a set of p-simplexes. With the help of the properties of this simplicial complex we also can associate with A certain intermediate structures. Using such structures we show how to solve various separability problems associated with A. When $p = 2$, A is a matrix and separability means A can be decomposed into a direct sum. When $p = 3$ there are four separability problems; when $p = 4$ there are fourteen, etc. We show how to solve these separability problems and establish certain theorems connecting them.

(158)

MONOCHROMATIC PATHS AND A 4-COLOR THEOREM FOR SURFACES OF GENUS g.

Kenneth A. Berman and Jerome L. Paul
University of Cincinnati

Let G be a graph of genus g. In this paper we show that the vertices of G can be 4-colored so that the longest monochromatic path has length at most 8g.

(159)

The Number of Classes under Permutation Equivalence of q-Valued $n_1 \times n_2 \times \cdots \times n_r$ Incidence Arrays

Spyros S. Magliveras,* University of Nebraska, Lincoln
Yi-Shang Shen, General Electric Company
Nicholas Tsolas, Bell Telephone Labs, Holmdel

The advent of VLSI techniques in the design of modern computer hardware has led to a new dimension in circuit realization of complex processes. In PLA's a high degree of simplification can be achieved by taking advantage of symmetries along each spatial dimension. In this paper we solve the following problem: What is the number of equivalence classes of $n_1 \times n_2 \times \cdots \times n_r$ arrays whose cells are filled by elements from a set Q of size q (the logic states), under the action of the group $\Sigma_{n_1} \times \Sigma_{n_2} \times \cdots \Sigma_{n_r}$. Here each symmetric group Σ_{n_i} acts along the i^{th} dimension of the array. The result is achieved by means of the character theory of the symmetric group, and repeated application of the Cauchy-Frobenius theorem.

(160)

DECOMPOSITION OF GRAPHS INTO ALTERNATING CIRCUITS

Badri Varma, Univ. of Wisconsin-Fox Valley

An alternating circuit A_k^*, k even is an orientation of cycle C_k of length k such that any two adjecnt arcs have opposite orientation. A decomposition of a digraph G into a digraph H is a partition of the arc set E(G) so that the resulting sub-digraphs are isomorphic to H. In this paper we explore an answer to the following:

Are the conditions which are necessary for the decomposition of a complete symmetric digraph or a complete symmetric bipartite digraph into alternating circuits of length k also sufficient?

ABSTRACTS OF CONTRIBUTED PAPERS

(161)

Invariants of Anti-symmetric Two-tensors

Tim R. McMillan

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ABSTRACT. A skew-symmetric tensor of step two is an element of the second homogeneous component, $\Lambda^2(V)$, of the exterior algebra $\underline{\Lambda}(V)$. The invariants of skew-symmetric two-tensors are the polynomials in the components of the tensors left invariant by the actions on $\Lambda^2(V)$ induced by the action of the general linear group on V. These invariants have geometric interpretations in terms of lines and screws. They can be realized as polynomials in the determinants (brackets) of the vectors of V. Here we characterize the bracket expressions that are invariants of two-tensors and give examples.

(162)

On An Iteration Diagram

Joe Hemmeter, University of Delaware

Let n be an integer greater than 1. Define a directed graph $D_n = (V_n, E_n)$ with vertex set $V_n = \{0,1,\ldots,n-1\}$ and edge set E_n, where, for $x,y \in V_n$, $(x,y) \in E_n$ if and only if $y \equiv x^2 \pmod{n}$. An attractor of D_n is just a directed cycle.

The attractors of D_n are studied, using elementary number theory. The results of this study can be used to figure out the number of (weak) components of D_n.

(163)

Orthomorphism Graphs of Z_p.

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An orthomorphism of Z_p, p an odd prime, is a bijection $\theta\ Z_p \to Z_p$, $\theta(0)=0$, such that the mapping $\eta\ Z_p \to Z_p$ defined by $\eta(x)=\theta(x)-x$ is also a bijection. The orthomorphism graph of Z_p, denoted $\mathrm{Orth}(Z_p)$, has as its vertex set the orthomorphisms of Z_p, two orthomorphisms θ, ϕ of Z_p being adjacent if the mapping $\delta\ Z_p \to Z_p$ defined by $\delta(x)=\theta(x)-\phi(x)$ is a bijection. An orthomorphism graph of Z_p is any induced subgraph of $\mathrm{Orth}(Z_p)$.

Orthomorphism graphs find applications in the construction of mutually orthogonal Latin squares and in the search for non-Desarguesian projective planes of prime order.

Known results on $\mathrm{Orth}(Z_p)$ will be surveyed and a conjectured structure of $\mathrm{Orth}(Z_p)$ will be presented.

(164)

"The Center of a Unicyclic Graph"

by

Preben Dahl Vestergaard

Abstract:

Let G be a connected graph with $|V(G)| = |E(G)|$. G has the unique circuit C. Define for $v \in V(G)$:

$$e(v) = \max\{d(v,w) \mid w \in V(G)\},$$
$$r_G = \min\{e(v) \mid v \in V(G)\},$$
$$\mathcal{C}(G) = \{v \in V(G) \mid e(v) = r_G\}.$$

Question: What is the structure of $\mathcal{C}(G)$?

The answer turns out to be that if $\mathcal{C}(G) \setminus V(C) \neq \phi$, then $\mathcal{C}(G)$ behaves as if G were a tree. Otherwise, $\mathcal{C}(G) \subseteq C$, and if $|V(C)|$ is even, then $\mathcal{C}(G)$ can be anything, but if $|V(C)|$ is odd, then no vertex of C can be joined to two distinct vertices of $\mathcal{C}(G)$. Conversely, for given C and $\mathcal{C} \subseteq C$ satisfying the above there exists a unicyclic graph G with circuit C and center $\mathcal{C}$. Analogously for a given tree T and $\mathcal{C} \subseteq T$ one can extend T to a unicyclic graph G with center $\mathcal{C}$.

ABSTRACTS OF CONTRIBUTED PAPERS

(165)

SOME REMARKS ON THE DOUBLE COMPETITION NUMBER OF A GRAPH

Kathryn F. Jones* and J. Richard Lundgren,
University of Colorado at Denver
Fred S. Roberts, Rutgers University and Suzanne Seager,
Carleton University

The competition graph of a digraph was introduced by Joel Cohen in 1968 and has been extensively studied by both graph theorists and ecologists. Recently (1985) Diny introduced the concept of the competition-common enemy graph and the related double competition number. Here we study this concept and provide a class of examples with arbitrarily large double competitions number.

(166)

Algorithms and Memory Requirements for Identifying Connected Components in Digital Images

Stephen J. Dow, The University of Alabama in Huntsville

In the context of image processing, the entries of a matrix are called pixels and adjacency between pixels is usually defined so that a given pixel is adjacent to either 4 or 8 neighboring pixels. A task commonly required by applications is the identification of maximal connected subsets of the set of pixels having a given property. A standard technique involves labelling the pixels in row major order and storing a table of equivalences between labels representing the same connected component. Memory limited versions of this algorithm are presented, as well as other algorithms which avoid the use of an equivalence table by searching each component as it is encountered. Lower bounds on the memory requirements are obtained by construction of bad (if not worst) case examples.

(167)

Quadratic Isomorphisms of $Z_p \oplus Z_p$-objects.

Neal Brand, North Texas State University

Let B and B' be isomorphic combinatorial objects each having $Z_p \oplus Z_p$ as vertex set and translations in $Z_p \oplus Z_p$ as automorphisms. Conditions on the automorphism group of B are given which imply that B and B' are isomorphic by a function whose coordinate maps are both quadratic. Examples of combinatorial designs are given which satisfy the conditions.

(168)

Subplanes in a minimum blocking set of PG(2,8)

Jane W. Di Paola, Cheyenne, Wy.

The known 13-member blocking set B in PG(2,8) consists of 3 5-lines having a common point c. We show that the points of B with the collinearity relations inherited from the plane form 12 subplanes with c as a common point. Using as a set of points, the points of B minus the point c, and as blocks, the sets of points in each subplane, we form a symmetric design which is not pairwise balanced. It has v=b=12, r=k=6, and each point appears 3 times with 8 other points and 2 times with 3 other points. The block intersection matrix of this design yields a strongly regular graph which is 3 copies of K_4.

In the absence of a general result on the size of subplane intersections, we have here a proving ground which records intersections of size 1,2,3,4. No intersection set is a quadrangle. This leaves open the supposition that any quadrangle in PG(2,8) lies in a unique subplane.

ABSTRACTS OF CONTRIBUTED PAPERS

(169)

Niche Graphs

Charles A. Cable*, Allegheny College

Kathryn F. Jones, J. Richard Lundgren
University of Colorado at Denver

If D=(V,A) is an acyclic digraph and G=(V,E) is a graph such that two vertices x and y are adjacent in G iff they have a common predator vertex or prey vertex in D, then G is called a niche graph. It is easy to show that not all graphs are niche graphs. However in many cases it is possible to adjoin a finite set of vertices, say I_m, to the vertex set V of both G and D, and also some additional arcs to the arc set to obtain G' and D' respectively where G' is a niche graph, $V' = V \cup I_m$ and E'=E. The smallest number of vertices that one must adjoin to G to obtain a niche graph is called the niche number of G. Some classes of niche graphs are investigated, including paths and cycles. We also calculate the niche number of some other graphs. An infinite class of graphs is exhibited in which none of the graphs in that class has a niche number.

(170)

Minimum Detour Methods For String Comparison

Frank Hadlock, Florida Atlantic University

The basic problem addressed here is that of comparing two strings or sequences, using the notion of distance due to Levenshtein. This problem has applications in spelling correction, in pattern recognition for signal processing, and in error correction for variable length codes. Computation of the distance has been typically accomplished by **dynamic programming** which is an **O(mn)** method, where **m**, **n** are the lengths of the two sequences or strings being compared. In this paper, lower bound formulas are developed as a basis for **minimum detour** computation of the string distance. In terms of the number of comparisons, dynamic programming is **O(mn)**, while the computation time of the minimum detour method is shown to be **O(nd)** where **n** is the maximum of **m,n** and **d** is the Levenshtein distance. While Ukonnen's method is also **O(nd)**, the minimum detour method is easily generalizable to the classification problem of finding the closest string in a set. Several special cases are shown to be **O(m)** and the method is shown to provide an efficient solution to the Longest Common Subsequence problem.

(171)

PERIPHERAL GRAPHS

Jenö Lehel
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Computer & Automation Institute, Budapest Hungarian Academy of Science

A graph is said to be peripherial if every induced subgraph G' contains a peripherial vertex, that is one which is simplicial either in G' or its complement $\bar{G}'$.
The family of peripheral graphs turns out to be a natural extension of chordal graphs and their complement. We show that peripheral graphs are perfectly orderable (and thus perfect) and propose the problem of finding structural characterization for the family.

(172)

A Bound for Blocking Sets of Maximal Type in Finite Projective Planes

Cyrus Kitto

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Gainesville, Florida 32611

ABSTRACT. We consider blocking sets S in finite projective planes Π of non-square order $n > 36$. If S is of maximal type, then it is proved that $|S| > n + \sqrt{n} + 3$.

ABSTRACTS OF CONTRIBUTED PAPERS

(173)

BICLIQUE PARTITIONS OF DIGRAPHS AND NONNEGATIVE MATRIX RANK

Kathryn F. Jones and J. Richard Lundgren*,
University of Colorado at Denver
John Maybee, University of Colorado at Boulder

The biclique partition number of a digraph, bp(D), is the minimum number of bicliques needed to partition the arcs of D and is equal to the nonnegative integer rank of the adjacency matrix of D. We find bp(D) for the complements of cycles and paths in a digraph. We use these results to find smallest possible biclique partitions for (n-2) - regular digraphs. We also discuss the more general problem for k - regular digraphs, including cases where the biclique partition number and cover number are equal as well as some interesting open questions.

(174)

SCHEDULING OF THE TASK GRAPHS INTO TRANSPUTER NETWORKS

E. B. Fernandez and T. A. Ngo - Florida Atlantic University

The Occam language is based on the concept of communicating sequential processes of Hoare. The transputer is a 32-bit microprocessor that incorporates some memory on the chip and has 4 communication links. We consider here the problem of scheduling a set of concurrent tasks, whose precedences are described by a partial order, into a transputer network. This scheduling must consider, additionally to the precedence constraints, delays due to the communication links. This is clearly a NP problem and heuristic solutions are of practical value. The language Prolog has been found to be a convenient way to express this type of algorithms.

(175)

Graphs and Bigraphs with Interval and Co-Interval Properties

Frank Harary, New Mexico State University
and
F.R. McMorris*, Office of Naval Research

Abstract

It has been proved by Akiyama, Ando and Harary (1983) as well as by Benzaken, Hammer, and de Werra (1984) that both a graph G and its complement are interval graphs if and only if G has no induced subgraph isomorphic to any of a list of seven graphs. We rederive this result as a simple corollary of a theorem of Lekkerkerker and Boland, and extend it to bipartite graphs.

(176)

Distribution Invariants of Association Schemes

N.Manickam, Department of Mathematics, DePauw University

Let X be a symmetric d-class association scheme and let V be the $|X|$ - dimensional euclidean space over R. Let $V = V_0 \mid V_1 \mid \ldots \mid V_d$ be the decomposition of V into maximal eigenspaces V_i $(0 \leq i \leq d)$ under the action of the associated Bose-Mesner algebra. Briefly speaking, the i^{th} distribution invariant is the minimum cardinality of a subset of the canonical base of V such that the projection of this set into V_1 lies on one side of a certain hyperplane (in V_1) through the origin. By using a simple counting argument and Erdös-Ko-Rado theorem very effectively, we calculate the first distribution invariants of several well-known association schemes. Also a nice geometric interpretation, called W-complement d-spreads is introduced for Singleton systems of certain orders.

ABSTRACTS OF CONTRIBUTED PAPERS

(177)

BICLIQUE COVERS AND PARTITIONS OF ACYCLIC DIGRAPHS

Kim A. S. Hefner* and J. Richard Lundgren
University of Colorado at Denver

We examine the minimum number of complete bipartite subgraphs needed to cover and partition acyclic digraphs. The minimums have an exact value for unilaterally connected digraphs, and bounds are obtained for weakly connected digraphs. We also solve the interpolation problem for each value within these bounds. The results are extended to examine the binary and nonnegative integer rank of a related class of 0-1 matrices.

(178)

THE FEASIBILITY PROBLEM FOR PROCESSING NETWORKS

S.C. Boyd, Dept. of Mathematics, Carleton University
J.W. Chinneck, Dept. of Systems Engineering, Carleton University

Processing networks are minimum cost flow problems in which for some nodes, the flows on arcs entering and leaving the node must do so in specified proportions. These networks arise naturally in many types of industrial models, such as models for chemical refining and energy systems.

We describe necessary and sufficient conditions for the existence of a feasible flow in a processing network. Furthermore, we give a polynomial method for checking these conditions which is based on bipartite matchings.

(179)

On Powers of Interval and Unit Interval Graphs

Arundhati Raychaudhuri
College of Staten Island (CUNY)
Staten Island, NY.

Abstract

In this paper, we consider how the properties of some important classes of graphs, G, are preserved in the k^{th} power, G^k, of G. If C represents a specific class of graph, then we ask the following question: if $G^{k-1} \in C$, is G^k in C for all positive integers $k \geq 2$? We show that the answer is affirmative when C is either the class of interval graphs or unit interval graphs.

(180)

The computational complexity of finding sub--generalized quadrangles of a generalized quadrangle

Clifton E. Ealy, Northern Michigan University

In this paper, I investigate the computational complexity of finding sub configurations of generalized quadrangles. In particular, I show that

If $Q = (\mathfrak{P}, \mathfrak{L})$ is a generalized quadrangle of order (s,t) and $\mathfrak{X}$ is a subset of $\mathfrak{P}$, then the full generalized quadrangle generated by $\mathfrak{X}$ can be determined in time polynomial in s and t and

If $Q = (\mathfrak{P}, \mathfrak{L})$ is a generalized quadrangle of order (s,t), then simplicity of Q can be determined in time polynomial in s and t.

ABSTRACTS OF CONTRIBUTED PAPERS

(181)

CONSTRUCTING RAMSEY GRAPHS WITH A COMPUTER

Geoffrey Exoo, Indiana State University

A technique for producing Ramsey-critical graphs with a computer is described. One difference between this and other computer based methods is that no symmetry assumptions are necessary. This work let to the determination of $f(K_5 - e)$, leaving R(5, 5) as the only unknown Ramsey number among graphs of order five. It also produced the construction which led to the determination of $r(K_4, K_5 - e)$, thereby completing all the entries in Clancy's table, except for that of R(4,5). Several new results are given.

(182)

CUTTING PLANES BASED ON BIN PACKING SOLUTIONS FOR THE CAPACITATED VEHICLE ROUTING PROBLEM

Gilbert LAPORTE* and Hélène MERCURE, Ecole des Hautes Etudes Commerciales de Montréal, 5255 avenue Decelles, Montréal H3T 1V6 Canada.
Yves NOBERT, Département des Sciences administratives, Université du Québec à Montréal, 1495, rue Saint-Denis, Montréal H3C 3P8 Canada.

This paper presents an integer linear programming formulation for the symmetrical capacitated vehicle routing problem (CVRP). This formulation includes degree constraints, integrality constraints and subtour elimination constraints based on bin packing solutions. The bin packing solutions are also used to derive comb inequalities for the CVRP. Computational results are reported.

(183)

Extensions of Permutation and Interval Graphs

D.G. Corneil* and P. A. Kamula, Dept. of Computer Science, University of Toronto.

Permutation graphs may be represented by a permutation diagram consisting of two parallel lines when one line has points numbered from 1 to n (the order of the graph) and the other line has points numbered by a permutation π of (1,.., n). Vertex i is adjacent to vertex j iff the line joining the two i points intersects the line joining the two j points. We extend this notion to PI and II graphs in the following way: For a PI graph each vertex is represented by a point on one line and an interval on the other. Two vertices are adjacent iff their corresponding triangles intersect. In an II graph each vertex is represented by an interval on each line and two vertices are adjacent iff their corresponding trapezoids intersect. In this talk we illustrate some properties of PI and II graphs with respect to various classes of perfect graphs.

(184)

Tight pointsets in finite generalized quadrangles

Stanley E. Payne, CU-Denver

A set A of points in a finite generalized quadrangle S is tight provided that on the average each point in A is collinear with the maximum number of points of A, in which case this number is constant over A and the characteristic function of A yields an eigenvector of the collinearity matrix associated with S. The determination of all tight sets is related to several difficult extremal problems in finite geometries and is undertaken here for quadrangles with small parameters. This leads to an interesting model of the classical geometry W(3).

ABSTRACTS OF CONTRIBUTED PAPERS

(185)

DOMATICALLY CRITICAL AND FULL GRAPHS

Douglas F. Rall
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A subset, D, of the vertex set of a graph G is a dominating set for G if each vertex of G is either in D or adjacent to some vertex in D. The maximum cardinality of a partition of the vertex set of G into dominating sets is the domatic number of G, denoted d(G). The domatic number and its relationship to other properties of a graph have been extensively studied since the introductory paper by Cockayne and Hedetniemi appeared in 1977. In this paper we consider domatically critical graphs and domatically full graphs (those where $d(G) = \delta(G) + 1$) and some of the relationships between these two classes of graphs.

(187)

Paper for 18th Southeastern Conference on Combinatorics, Graph Theory and Computing, February 23-27, 1987 at Boca Raton, Florida.

RECENT RESULTS ON COLOURING PRIME DISTANCE GRAPHS

Roger B. Eggleton*, University of Newcastle, Australia (*speaker)
Aviezri S. Fraenkel, Weizmann Institute of Science, Israel.

ABSTRACT A *prime distance graph* $Z(D)$ is a graph with the integers as vertex set and an edge between two vertices x, y precisely when $|x-y| \in D$, where the *distance set D* is any given subset of the primes. Eggleton, Erdös and Skilton [J. Combinatorial Theory, Ser. B, 39 (1985),86-100] introduced prime distance graphs. They showed that any prime distance graph has chromatic number at most 4, characterized all cases with chromatic number 1 or 2, and gave several infinite families with chromatic number 3. The same authors [Discrete Math. 58 (1986), 323] proposed a Four Colour Problem for Primes: For which minimal subsets D of the primes does $Z(D)$ have chromatic number 4? Such subsets must contain 2 and 3; they knew in addition that the presence of two twin primes is sufficient, and conjectured that this is also necessary. However, they subsequently found counterexamples; in particular the prime distance graphs $Z(2, 3, p, p+8, 2p+13)$ are 4-chromatic. Thus the Four Colour Problem for Primes remains open.

(186)

UNIVERSAL TRAVERSAL SEQUENCES FOR PATHS AND CYCLES

Michael F. Bridgland, The MITRE Corp., Bedford, MA

It is not known whether the reachability problem for rooted undirected graphs G (Is a given vertex v in G reachable from the root?) can be solved in space $O(\log |V(G)|)$. One approach to this problem involves neighbor labelings, i.e., families $\Lambda = \{\lambda_v; v \in V(G)\}$ of bijections $\lambda_v: \{1, 2, \ldots, \delta(v)\} \longrightarrow N(v)$, where $N(v)$ and $\delta(v)$ denote the set of neighbors of v and the degree of v, respectively. For each such Λ, every sequence $(\sigma_k)_{k \geq 1}$ of positive integers generates a sequence of vertices $(w_k)_{k \geq 0}$ in G beginning at the root such that consecutive pairs of vertices are adjacent or identical: if $\sigma_{k+1} \leq \delta(w_k)$, then $w_{k+1} = \lambda_{w_k}(\sigma_{k+1})$; otherwise, $w_{k+1} = w_k$. If all vertices of G appear in the sequence generated by (σ_k) for every connected graph G with at most n vertices, none of which has degree greater than k, and each neighbor labeling Λ of G, then (σ_k) is said to be an *(n, d)-universal traversal sequence*. The existence of (n, d)-universal traversal sequences is easy to verify, but known methods for their construction involve some sort of exhaustive search. In this talk, a recursive algorithm for the construction of $(n, 2)$-universal traversal sequences in space $O(\log^2 n)$ will be presented.

(188)

ON A SEMI-TRANSLATION PLANE OF ORDER 16

Marialuisa J. de Resmini, Dip. Mat. Univ. Roma "La Sapienza", Rome

Some combinatorial properties are investigated of the classical semi-translation plane of order 16, say π. This plane is obtained from the Desarguesian plane of the same order by the following sequence of operations: derive, dualize, and derive.

Generating quadrangles, subplanes and their distribution, and complete arcs are considered in π.

Finally, the results are compared with the analogous ones in the Lorimer plane and in the Desarguesian plane.

ABSTRACTS OF CONTRIBUTED PAPERS

(189)

SQUARE-STAR REDUCTION AND ITS FORBIDDEN GRAPHS

Sajal K. Das and Narsingh Deo*, University of Central Florida

Series-parallel and Δ–Y transformations have been used by electrical engineers in network analysis for decades. We carry them a step further and define a new graph transformation, called the square-star (*SS*) reduction, where a 4-cycle (square) is replaced with a star with four edges. A graph is purely square-star (*PSS*)-reducible if it can be reduced to an edge or a triangle by recursive applications of series-parallel and *SS*-reductions. If Δ–Y reductions are also used to get an edge, the graph is called extended square-star (*ESS*)-reducible. The class of *SS*-reducible (union of *PSS*- and *ESS*-reducible) graphs defines a new class containing planar and nonplanar graphs. We identify the smallest biconnected, planar and nonplanar graphs forbidden for *PSS*- and *ESS*-reductions; and study some of their properties including colorings, eigenvalues, automorphism groups, and symmetries. We observe that the *SS*-reduction does not preserve planarity, nonplanarity, or subgraph homeomorphicity Also the reduction of any arbitrary square in an *SS*–reducible graph may yield a non-*SS*-reducible graph.

(191)

Coloring Real Quadratic Extensions of $\mathbb{Q}^2$

Peter D. Johnson Jr., Auburn University

Let $D_0 = \{\sqrt{p/q} : p, q$ are odd positive integers$\}$

Theorem 1. If m is an odd square-free positive integer, then $[\mathbb{Q}(\sqrt{2m})]^2$ can be two-colored so that all the distances D_0 are forbidden.

Theorem 2. If $m-1$ is square-free and $m \equiv 1 \mod 4$, then $[\mathbb{Q}(\sqrt{m})]^2$ can be four-colored so that all the distances D_0 are forbidden.

(190)

OPTIMUM ZOO-KEEPER ROUTES

Wei-Pang Chin and Simeon Ntafos*
The University of Texas at Dallas

Abstract: We consider the problem of finding a shortest route that visits (without entering) a set of convex polygons attached to the interior of the boundary of a simple polygon (zoo-keeper route). One may think of this as designing a route for a zoo-keeper that wants to feed a number of animals in cages. We present an $O(n^2)$ algorithm for this problem, where n is the total number of vertices in the various polygons. We also discuss the extension of this algorithm to the case when the route is allowed to go through the convex polygons. These algorithms are useful in finding watchman routes in simple polygons, where a watchman route is one with the property that each point in a given space is visible from at least one point along the watchman route.

(192)

A Nonlinear Flock in the Minkowski Plane of Order 11

R. D. Baker* and G. L. Ebert, University of Delaware

A hyperbolic (ruled) quadric in $PG(3,q)$, q odd, is conveniently given by the equation $x^2 - \alpha y^2 + \alpha z^2 - w^2 = 0$ for some nonsquare α of $GF(q)$. The points and plane sections of such a quadric are the points and circles of a Minkowski plane. A partition of the $(q+1)^2$ points into $q + 1$ disjoint circles is called a flock. A flock is linear when the planes of its circles contain a common line. M. Walker and J. A. Thas independently discovered a construction for a translation plane from a flock. The translation plane is Desarguesian if and only if the flock is linear, and hence there is great interest in finding nonlinear flocks. Thas [1975] showed that for odd q one may obtain a flock as the union of half the circles from each of two conjugate linear flocks, and has conjectured that these are the only nonlinear flocks. We show that this conjecture by Thas is false by constructing a new nonlinear flock for $q = 11$.

ABSTRACTS OF CONTRIBUTED PAPERS

(193)

Probabilistic Advantages in High Sum Wins Contests

John W. Hilgers
Michigan Technological University

Consider two random variables X and Y. If N samples of both are taken and the sums $S_X^N = \sum X$, and S_Y^N formed, define $X_N \gtrsim Y_N$ to mean Prob $\{S_X^N > S_Y^N\} \gtrsim$ Prob $\{S_X^N < S_Y^N\}$.

Let rel_N be the relation appropriate to integer N. We investigate the nature of the sequence $\{rel_N\}$ when the first r moments of X and Y are identical.

(195)

New bounds on dominating number of grid graphs

E. Regener* and T.N.M. Vo, Concordia University, Montreal

We have some constructions for dominating sets on h×w grid graphs, which relax in certain ways the condition that no neighbourhoods overlap in the interior of the graph. For widths up to 12 these sets are smaller in the limit than those obtained using "star centres" only. The constructions cannot give improved bounds if (h-13)(w-13) > 45. We give a conjecture on the structure of dominating sets which would prove optimal the bounds obtained.

(194)

Spanning trees of k-trees

Robert P.J. Day
University of Waterloo

One of the most popular measures of network reliability continues to be the all-terminal reliability of the underlying graph -- that is, the probability that there exists a spanning connected subgraph of the network in an environment of (statistically independent) link failures and perfectly reliable nodes. In the situations where obtaining this measure is computationally intractable, we may have to be content with more primitive measures of reliability, two examples being the number of spanning connected subgraphs and the number of spanning trees. In this paper, we restrict our attention to a particular subclass of series-parallel graphs known as k-trees, review some of the reliability results for the case of k=2, and show which of the results for 2-trees are extensible to 3-trees in particular and k-trees in general.

(196)

New *t*-Designs Found by Basis Reduction

Donald L. Kreher and Stanisław P. Radziszowski

School of Computer Science and Technology
Rochester Institute of Technology

ABSTRACT

At the Seventeeth Southeastern International Conference on Combinatorics, Graph Theory and Computing we presented a new algorithm for finding t-(v,k,λ) designs without repeated blocks. The central idea of the algorithm was basis reduction. This year we report on the success we have had using it. Namely, the construction of several new simple t-designs including a 4-(12,6,10) design, a 6-(14,7,4) design and 5-(28,6,λ) designs for each λ, $\lambda \neq 1$ (or 22).

ABSTRACTS OF CONTRIBUTED PAPERS

(197)

NEIGHBORHOOD CONDITION AND EDGE DISJOINT HAMILTONIAN CYCLES

R. J. Gould, Emory University; R. J. Faudree* and R. H. Schelp,
Memphis State University

A graph G satisfies the neighborhood condition $NC(G) \geq m$, if for each pair of nonadjacent vertices of G, the union of their neighborhoods is at least m. For k a fixed positive integer, let G be a graph of order n which satisfies the following conditions: $\delta(G) \geq 4k$, $\kappa_1(G) \geq 2k$, $\kappa_1(G-v) \geq k$ for any vertex v in G, and $NC(G) \geq (2n + C)/3$ for some constant C. If n is sufficiently large, then G contains k edge disjoint Hamiltonian cycles. Corresponding conditions give disjoint perfect matchings.

(198)

LOWER BOUNDS FOR THE CAPACITY OF ODD CYCLES

Brian Dorner, Chris Meyer and M. Rosenfeld,
Department of Mathematics and Computer Science,
Pacific Lutheran University

(199)

A Binary Tree Framework for the Collatz 3x + 1 Problem

M. Dolan and S. Manickam*, Western Carolina University, Cullowhee, NC 28723

For the $3x + 1$ conjecture that, given $m \in N$, the sequence $\{m_n\}$ defined iteratively by $m_o = m$, $m_{n+1} = (3m_n+1)/2$ if m_n is odd, and $m_n/2$ if m_n is even, has some iterate $m_j = 1$, Lagarias [1] presents an infinite directed graph of iterates, called the Collatz graph. The conjecture then states that the Collatz graph on N is weakly connected. Nievergelt et al [2] study this graph, with an inverse formulation of the conjecture, and make useful empirical observations. Everett [3] proves that the finite part $\{x_o,\ldots,x_{k-1}\}$ of the parity sequence $\{x_n\}$ is in one-to-one correspondence with an $m \in N_k$, where $N_k = \{0,1,\ldots,2^k-1\}$. This is shown here to provide an infinite binary tree framework for the conjecture, upon defining sequences $\{a_n\}$, $\{b_n\}$ by

i) if $x_o = 0$, then $a_o = 0 = b_o$; if $x_o = 1$, then $a_o = 1$, $b_o = 2$;

ii) if x_n and b_{n-1} have the same parity, then $a_n = a_{n-1}$, $b_n = G(b_{n-1})$,

iii) otherwise, $a_n = a_{n-1} + 2^n$, $b_n = G(b_{n-1} + 3^{F_n})$,

where $F_n = \sum_{i=0}^{n-1} x_i$, and $G(n) = n/2$ for n even and $G(n) = (3n+1)/2$ for n odd.

[1] Amer. Math. Monthly, 92(1985) 3-23.
[2] Computer Approaches to Mathematical Problems, Prentice-Hall, 1974.
[3] Adv. Math., 25 (1977) 42-45.

(200)

ON EDGE-GRACEFUL LABELLINGS OF COMPLETE GRAPHS - A SOLUTION OF LO'S CONJECTURE

LI-MING LEE, SIN-MIN LEE* & GITA MURTHY
Dept. Maths. & Computer Science, San Jose State University, San Jose, CA

This paper deals with the edge graceful labellings of complete graphs. Error was detected in the algorithim for complete graphs with odd number of nodes which is suggested by Sheng-Ping Lo in Congressus Numerantium 50 (1985), 231-241. New algorithms of edge graceful labellings for K_n where $n \neq 2 \pmod 4$ are given.

This prove that K_{4n} is edge graceful for all n.

ABSTRACTS OF CONTRIBUTED PAPERS

(201)

Diameters of Double Loop Local Computer Networks

Ying Cheng, Department of Mathematics, Louisiana State University

Abstract. Recently double loop local computer networks have been studied extensively. The study of these networks is mainly due to the consideration of reliability, delay and nodal processing limitations of single loop local computer networks. The topology of a double loop local computer network can be described by a directed graph as follows. Let n and h be integers such that $n \geq 3$ and $2 \leq h \leq n-1$. $G(n,h)$ is defined as the directed graph with vertex set $Z/nZ = \{0,1,\ldots,n-1\}$ and directed edges $i \to i+1 \pmod n$ and $i \to i+h \pmod n$ for every vertex $i \in Z/nZ$. The purpose of this paper is to study the diameter of $G(n,h)$, denoted by diam $G(n,h)$. The diameter is one of the major factors in the evaluation of a network. We will give a formula for diam $G(n,h)$. The formula involves four numbers which are related to interesting problems in number theory. We solve these problems by providing an algorithm based on Euclidean algorithm of finding greatest common divisor of n and h. We also point out some incorrect analysis of double loop local computer networks in the literature.

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Triangles in 3-connected matroids.

Talmage James Reid, Louisiana State University.

Abstract. A collection F of 3-connected matroids is triangle-rounded if, whenever M is a 3-connected binary matroid having a minor in F, and T is a 3-element circuit of M, then M has a minor in F using T. A theorem for testing a collection of matroids for this property is presented. When T is an arbitrary subset of M, corresponding results were proved by Seymour for T of size at most 2 and by Bixby and Coullard for T of size at least 3.

(203)

A SURVEY OF DERIVED GRAPHS

ARTHUR M. HOBBS, Texas A&M University

This paper discusses line graphs, powers of graphs, total graphs, and similar derived graphs. Each of these classes of graphs has a description in terms of complete subgraphs and their intersection properties. Further, L. Nebesky has described a mechanism he calls the "partial square of a graph" that can be used to describe squares and line graphs. This paper examines the literature of derived graphs.

(204)

METHOD FOR TESTING EQUIVALENCE OF HETEROGENEOUS RELATIONAL DATABASES

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A method for testing the constraint structure equivalence of two heterogeneous relational database schemes is presented. The constraint structure over a database scheme is a binary relation over the topology in a topological space defined over the finite attribute set. In the event that the two database schemes are equivalent, the technique generates a mapping between the two attribute sets. It is shown that the use of topological spaces defined over the attribute sets provide a useful intermediate step in the process. A means of determining the most useful topology (optimal topology in minimal size) for the process is also described.

ABSTRACTS OF CONTRIBUTED PAPERS

(205)

A BRANCH-AND-CUT ALGORITHM FOR THE RESOLUTION OF LARGE SCALE SYMMETRIC TRAVELING SALESMAN PROBLEMS

Giovanni Rinaldi: IASI - CNR viale Manzoni 30, Roma Italy and New York University, 40 W 4th str. Room 524, New York, 10003 N.Y.

A branch-and-cut algorithm is presented for the resolution of large scale symmetric traveling salesman problems.
The basic idea of branch-and-cut marries linear programming based cutting planes techniques with branching techniques.
The cuts generated by the algorithm are inequelities that define facets of the TSP polytope, and that are violated by the optimal solution of a LP relaxation. The identification of violated inequalities is carried out by exact algorithms for the so-called subtour elimination and the 2-matching constraints and by efficient heuristics for the comb and clique-trees constraints.
Computational results are reported on a wide sample of test problems solved to optimality by the algorithm. The sizes of these problems ranges from 100 to more than 2000 cities.

(206)

On (0, 1)-matrices and bipartite graphs.

Rodica Simion, Department of Mathematics, Bryn Mawr College, Bryn Mawr, PA 19010.

Let A be a nonsingular (0, 1)-matrix. We discuss two problems formulated by C.D. Godsil concerning the positions occupied by the non-zero entries in A and A^{-1}, and offer a solution to one of them. A bipartite graph G with unique perfect matching corresponds to an invertible (0, 1)-matrix, $A(G)$, which can be assumed to be (lower) triangular. We give a complete characterization of the graphs G such that the inverse of $A(G)$ is diagonally similar to a matrix corresponding to a graph isomorphic to G.

(207)

ON MAXIMAL-IMMUTABLE SETS

Ernst L. Leiss [1,2]
Farokh B. Bastani [1,3]

A laser disk is a storage device where for technical reasons, a 0 can be changed into a 1, but a 1 can never be changed into a 0. Given two binary strings v and w of length k, we say v can be subverted into w iff w has a 1 in every position where v has a 1. A set $S \subseteq \{0,1\}^k$ is called immutable iff no string $v \in S$ can be subverted into any other string $w \in S$. A set S is called maximal-immutable iff it is immutable and for any $x \in \{0,1\}^k - S$, $S \cup \{x\}$ is not immutable. The aim of this paper is to pose some interesting problems related to maximal-immutable sets and to illustrate the difficulties in obtaining answers to them.

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GRACEFUL QUADRATIC GRAPHS AND SKOLEM SEQUENCES

Jaromir Abrham, Department of Industrial Engineering, University of Toronto, Toronto, Ontario Canada, M5S IA4

It is shown that all graceful valuations of certain quadratic graphs on n vertices can be obtained from certain Skolem sequences of order n+1.

ABSTRACTS OF CONTRIBUTED PAPERS

(209)

A Relationship between Convex Programming, LYM Property, and Perfect Graphs

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We derive three equivalent conditions concerning (i) a convex programming problem, (ii) the length-width inequality, and (iii) the simultaneous vertex-covering by cliques and anticliques, on a perfect graph G. By combining proof techniques including Lagrangian dual, Dilworth's Theorem, and Kuhn-Tucker Theorem, we establish a strong connection between the three topics. This provides new insights into the structure of perfect graphs. As a bonus, the famous Lubell-Yamamoto-Meschalkin (LYM) Property or Sperner Property for partially ordered sets is a specialization of our results.

(210)

A DISCRETE EXPONENTIATION CRYPTOSYSTEM

G.B. Agnew*, R.C. Mullin, I. Onyszchuk, S.A. Vanstone, Univ Waterloo

In 1976, Diffie and Hellman introduced the notion of public Cryptography. Since that time, 3 basic types of public key systems have been advanced: Cryptosystems based on i) the factoring problem, ii) the discrete logarithm problem iii) the knapsack problem. Of these, only the first 2 remain of cryptographic interest.

The RSA system is based on the difficulty of factoring a number formed as the product of 2 large primes. This system [with a few restrictions placed on the primes used], constitutes a viable cryptosystem. Interest in systems based on the difficulty of finding logarithms over a finite field [referred to as discrete exponentiation distance] suffered due to results obtained for fields of small size.

[E.G. GF[2^{127}]]. This paper examines a discrete exponentiation cryptosystem based on fields of over 1,000 bits and its VLSI implementation.

(211)

On the proof of Winkler's four-thirds conjecture

Ervin Győri

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Let $\mu(G)$ be the mean distance of the connected graph G. Winkler conjectured that

(a) any connected graph G has a vertex whose removal increases $\mu(G)$ by no more than a factor 4/3

(b) any 2-edge-connected graph G has an edge whose removal increases $\mu(G)$ by no more than a factor 4/3.

In this talk, we present the basic ideas of the proof of the edge version and how the asymptotic correctness of the vertex version can be derived from it.

(212)

ON EDGE GRACEFUL UNICYCLE GRAPHS

SIN-MIN LEE, QUAN KUANG* & ANN-GAU WANG
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We conjectured that every finite unicycle graph with odd number of nodes is edge graceful. We prove this conjecture for some special cases.

ABSTRACTS OF CONTRIBUTED PAPERS

(213)

A Purely Combinatorial Pivoting Method for Generalized Feasible Circulation over Real Spaces

Zhemin WANG, Dept. of Management Sciences, University of Waterloo.

ABSTRACT: Let E be a finite set and V, V* a pair of complementarily orthogonal subspaces of R^E. For every $e \in E$, a lower bound ℓ_e and an upper bound m_e are given such that: $\ell_e \le m_e$ and $-\infty < m_e \le +\infty$ and $-\infty \le \ell_e < +\infty$. Fulkerson generalized Hoffman's feasible circulation theorem over cycle spaces and proved to the following generalized feasible circulation theorem over real spaces.

Theorem. Exactly one of the following two statements hold:

(a) $\exists x \in V$ such that $\forall e \in E \Rightarrow \ell_e \le x_e \le m_e$;

(b) $\exists y \in V^*$ such that $\sum_{y_e>0} y_e \ell_e + \sum_{y_e<0} y_e m_e > 0$.

This paper gives a finite pivotal algorithm which constructively realizes the above theorem using purely combinatorial pivoting rules i.e., they involve no process of minimum-ratio-test and work only on a smallest-label principle.

(215)

Immunity to Subgraph Failures in Communication Networks

Arthur M. Farley and Andrzej Proskurowski
University of Oregon

A network is *immune* to a set of failures *F* if message transfer can be completed in the presence of *F*. In this paper, we decribe networks immune to certain classes of *templated failures*. A templated failure is characterized by (possibly more than one) connected graph, a template; elements of a given network that belong to a subgraph isomorphic with a template can fail together as a dependent failure. We discuss templates that can be described by graphs induced by one vertex and a subset of its neighbors. We first deal with immunity to single templated failures. We then consider networks immune to sets of isolated failures, where no two adjacent elements of the network may fail. We describe minimal classes of graphs immune to sets of isolated failures with $K_{1,1}$ template.

(214)

The Representation Theory of a Tactical Configuration

Ken W. Smith, Central Michigan University, Mt. Pleasant, MI 48859,

The representation theory of various designs have been introduced by Kilmoyer and Solomon, Ott, and Liebler. This theory uses an algebra $\mathfrak{H}$ on the flags of the design which is a homomorphic image of the group algebra of a dihedral group.

The results of the earlier authors will be briefly summarized. Then the relationships between the dimension of $\mathfrak{H}$ and Neumaier's rank of a design will be given. In addition, the explicit connection between the dimension of $\mathfrak{H}$, the rank of the design and certain counts on walks in the flag graph will be developed.

Finally, the smallest dimensional cases (dim $\mathfrak{H} \le 10$) will be classified.

(216)

ON SKOLEM-GRACEFULNESS OF 4-STARS.

by SIN-MIN LEE , SONNY WANG and INDRA WEI*
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A graph $G=(V,E)$ is said to be Skolem graceful if there exists a bijection $f: V \to \{1,2,\ldots,|V|\}$ such that the induced mapping $f^*: E \to \{1,2,\ldots,|E|\}$ which is defined by

$$f^*(a,b)=|f(a)-f(b)|$$

is a bijection.

For $k \ge 2$, a k-star $St(a_1,\ldots,a_k)$ is a disconnected graph with k stars $St(a_1),\ldots,St(a_k)$.

Lee and Wei showed that for k=2 and 3 , a k-star is Skolem graceful iff not all a_i is odd.

We conjecture that all 4-star is Skolem graceful. Some partial results are obtained.

ABSTRACTS OF CONTRIBUTED PAPERS

(217)

Two Efficient Algorithms for Finding a Penalty-Minimizing Line for Linear Prediction. Sue Walker Toledo Boca Raton

Consider an L_1 approximation problem in which a penalty is incurred for error in prediction that is proportional to the size of the error. Thus there are two positive numbers F and G such that if (U,V) is a point in a set of sample points S, and the line Y = A + BX is used for the prediction of Y values from X values, then a penalty of

F*(V - A - BU) is incurred for the point (U,V) if V > A + BU, and a penalty of

G*(A + BU - V) is incurred for the point (U,V) if V < A + BU.

Here F and G are called the **penalty factors** of the problem. When F = G the line that minimizes the sum of the penalties over all the points in S is also the line that minimizes the sum of the absolute values of the vertical distances from the points in S to the line. Linear programming techniques are known to be applicable to this problem.

The speaker will compare two methods of finding a penalty-minimizing line, one a highly refined version of the simplex method, and one based on the two-dimensional geometry of the problem. The second is significantly more efficient than the simplex approach. The special simplex method, however, is very efficient in terms of both time and space when compared with the basic simplex method, and can be easily generalized to the case of a Y variable depending on several independent variables.

(218)

TILING INTERVALS WITH TRIPLES

Aaron Meyerowitz -- Florida Atlantic University

Consider the set $S=\{0,2,5\}$. The interval $[0,17]$ can be partitioned into subsets all of which are directly or reflectively isomorphic to **S** (i.e. translates of **S** or of its reflection) : $\{0,2,5\}\cup\{1,3,6\}\cup\{4,7,9\}\cup\{8,10,13\}\cup\{11,14,16\}\cup\{12,15,17\}$. We give a constructive proof that every 3-set in $\mathbb{Z}$ similarly tiles some interval and discuss related results and conjectures for tiling in one and several dimensions. The two dimensional analogue, tilings in $\mathbb{Z}^2$, amounts to tiling on an infinite checkerboard (with possibly disconnected pieces).

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The Platonic Coloring Conjectures

Steve Fisk, Bowdoin College

If all the faces of a graph embedded in the sphere are triangles (resp. squares) (resp. pentagons) we conjecture that there are maps from X to the tetrahedron (resp. cube) (resp. dedecahedron). The case of the triangle and tetrahedron is the Four Color Theorem. We present evidence for these conjectures.

(220)

ON SKOLEM GRACEFULNESS OF PATH UNION STAR.

by SIN-MIN LEE , LILIAN QUACH and SONNY WANG*

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We completely determine which m,n ≥ 2 so that $P_n \cup St(m)$ is Skolem graceful.