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B. S. Panda · Partha P. Goswami (Eds.)

Algorithms and Discrete Applied Mathematics

4th International Conference, CALDAM 2018 Guwahati, India, February 15–17, 2018 Proceedings

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Editors
B. S. Panda
Indian Institute of Technology Delhi
New Delhi
India

Partha P. Goswami
University of Calcutta
Kolkata
India

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Preface

This volume contains the papers presented at CALDAM 2018: the 4th International Conference on Algorithms and Discrete Applied Mathematics held during February 15–17, 2018, in Guwahati. CALDAM 2018 was organized by the Department of Computer Science and Engineering, Indian Institute of Technology, Guwahati. The conference had papers in the areas of algorithms, graph theory, codes, polyhedral combinatorics, computational geometry, and discrete geometry. The 68 submissions had authors from 12 different countries. Each submission received at least one detailed review and nearly all were reviewed by three Program Committee members. The committee decided to accept 23 papers. The program also included four invited talks by Andreas Brandstädt, Sathish Govindarajan, J. Mark Keil, and Miklós Simonovits.

The first CALDAM was held in February 2015 at the Indian Institute of Technology, Kanpur, and had 26 papers selected from 58 submissions from ten countries. The second edition was held in February 2016 at the University of Kerala, Thiruvananthapuram (Trivandrum), India, and had 30 papers selected from 91 submissions from 13 countries. The third edition was held in February 2017 at Birla Institute of Technology and Science, Pilani (BITS Pilani), K. K. Birla Goa Campus, Goa, India, and had selected 32 papers from 103 submissions from 18 countries.

We would like to thank all the authors for contributing high-quality research papers to the conference. We express our sincere thanks to the Program Committee members and the external reviewers for reviewing the papers within a very short period of time. We thank Springer for publishing the proceedings in the *Lecture Notes in Computer Science* series. We thank the invited speakers Andreas Brandstädt, Sathish Govindarajan, J. Mark Keil, and Miklós Simonovit for accepting our invitation. We thank the Organizing Committee chaired by R. Inkulu from the Indian Institute of Technology, Guwahati, for the smooth functioning of the conference. We thank the chair of the Steering Committee, Subir Ghosh, for his active help, support, and guidance throughout. We thank our sponsors Google Inc., Microsoft Research India, and the National Board of Higher Mathematics, Department of Atomic Energy, for their financial support. We also thank Springer for its support for the two Best Paper Presentation Awards. Last but definitely most importantly, we thank the EasyChair conference management system, which was very effective in handling the entire reviewing process.

December 2017

B. S. Panda
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Abstracts of Invited Talks

Efficient Domination and Efficient Edge Domination: A Brief Survey

Andreas Brandstädt

Institut für Informatik, Universität Rostock, 18051 Rostock, Germany
andreas.brandstaedt@uni-rostock.de

Abstract. In a finite undirected graph $G = (V,E)$, a vertex $v \in V$ *dominates* itself and its neighbors in G. A vertex set $D \subseteq V$ is an *efficient dominating set* (*e.d.s.* for short) of G if every $v \in V$ is dominated in G by exactly one vertex of D.

The *Efficient Domination* (ED) problem, which asks for the existence of an e.d.s. in G, is known to be $\mathbb{NP}$-complete for bipartite graphs, for (very special) chordal graphs and for line graphs but solvable in polynomial time for many subclasses. For H-free graphs, a dichotomy of the complexity of ED has been reached.

An edge set $M \subseteq E$ is an *efficient edge dominating set* (*e.e.d.s.* for short) of G if every $e \in E$ is dominated in G by exactly one edge of M with respect to the line graph $L(G)$. Thus, M is an e.e.d.s. in G if and only if M is an e.d.s. in $L(G)$. An e.e.d.s. is called *dominating induced matching* in various papers.

The *Efficient Edge Domination* (EED) problem, which asks for the existence of an e.e.d.s. in G, is known to be $\mathbb{NP}$-complete even for special bipartite graphs but solvable in polynomial time for various graph classes.

The problems ED and EED are based on the $\mathbb{NP}$-complete Exact Cover problem on hypergraphs.

The Use of Dynamic Programming in Intersection Graphs

J. Mark Keil

Department of Computer Science, University of Saskatchewan, Canada

Abstract. The intersection graph of a family $\mathcal{F}$ of sets is the graph having $\mathcal{F}$ as the node set with two elements of $\mathcal{F}$ adjacent in the graph if and only if their intersection is nonempty. For example, the intersection graphs of subtrees of a tree are the chordal graphs. A graph G is a geometric intersection graph if G is the intersection graph of a set of geometric objects. If the geometric objects are intervals of the real line, then interval graphs are formed. String graphs are the intersection graphs of curves in the plane and they are among the most general geometric intersection graphs that have been studied. String graphs are a superclass of planar graphs, chordal graphs, and circle graphs. The restriction that each string touches the infinite face of the plane results in the class of outerstring graphs.

Let $G = (V, E)$ be an undirected graph with n nodes and m edges. For two specified nodes s and t in V, the k most vital nodes in G are those $k, (1 \leq k \leq n-2)$ nodes whose removal maximizes the increase in the length of the shortest path from s to t. The problem of identifying the k most vital nodes was defined by Corley and Sha [3] in 1982 as a way to identify locations in a network that may need to be reinforced against an interdictor or a natural disaster, and shown to be NP-complete by Bar-Noy, Khuller and Schieber in 1995 [1]. In this talk I will describe polynomial time dynamic programming algorithms for the k most vital nodes problem for some classes of intersection graphs, namely interval graphs, chordal graphs, permutation graphs and interval bigraphs. This is joint work with Leizhen Cai [2].

I will also describe a dynamic programming algorithm to the maximum weight independent set problem in an outerstring graph which is polynomial in the size of the geometric input representation of the graph. This result is joint work with D. Pradhan, J. Mitchell and M. Vatshelle [4].

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Extremal Graph Theory, Stability, and Anti-Ramsey Theorems

Miklós Simonovits

Alfréd Rényi Mathematical Institute of the Hungarian Academy of Sciences, Budapest

Extremal graph theory is one of the most developed branches of Discrete Mathematics. Stability methods introduced by the author [5] are very successful to prove sharps results in this field. We shall give some illustration of this method for graphs, hypergraphs, (among others, the Füredi-Simonovits and Füredi-Pikhurko-Simonovits theorems obtained by the Stability methods). We shall also apply stability methods to Anti-Ramsey problems. An ANTI-RAMSEY problem is where a sample graph L is fixed and we colour, e.g., the edges of a complete graph K_n without having a copy of L in which all the edges have distinct colours.

Several problems in combinatorics can be reduced to extremal graph problems. Erdős, Simonovits and Sós [4] basically reduced certain ANTI-RAMSEY problems to extremal graph problems. Some others, like the problem of $L = C_k$ were much more difficult.

In the lecture we shall also consider Dual ANTI-RAMSEY problems, coming from Theoretical Computer Science. Burr, Erdős, Graham and T. Sós [1] defined and investigated a *dual* variant of the ANTI-RAMSEY problems. Some of their results also can be found in a second paper joint with Peter Frankl [2]. As they pointed out, one of the most interesting cases they could not settle was that of C_5.

The dual Anti-Ramsey problem. Let us fix a sample graph L, and consider a (variable) graph G_n on n vertices, with

$$e = e(G_n) > \mathrm{ex}(n, L)$$

edges. Let $\chi_S(G_n, L)$ denote the *minimum* number of colours needed to colour the edges of G_n so that no $L \subseteq G_n$ has two edges of the same colour. Determine

$$\chi_S(n, e, L) := \min\{\chi_S(G_n, L) : e(G_n) = e\}.$$

Here we improve several results of [1] and [2]. We shall prove, among others, that if a graph G_n has $e = \left\lfloor \frac{1}{4} n^2 \right\rfloor + 1$ edges and we colour its edges so that every $C_5 \subset G_n$ is 5–coloured, then we have to use at least $\left\lfloor \frac{n}{2} \right\rfloor + 3$ colours, if n is sufficiently large. This result is sharp.

Theorem 1 (Erdős-Simonovits). *There exists a threshold n_0 such that if $n > n_0$, and a graph G_n has $\left\lfloor \frac{1}{4} n^2 \right\rfloor + 1$ edges and we colour its edges so that every C_5 is 5–coloured, then we have to use at least $\left\lfloor \frac{n}{2} \right\rfloor + 3$ colours.*

Theorem 2. *There exists a function* $\vartheta(n) \to \infty$ *such that if* $0 < k = \binom{h}{2} < \vartheta(n)$, *then the upper bound of Theorem 4.2/[1] is sharp for* $e = \lfloor \frac{1}{4}n^2 \rfloor + k$:

$$\chi_S(n, e, C_5) = (h+1)\left\lfloor \frac{n}{2} \right\rfloor + k.$$

Because of the monotonicity, this implies

Theorem 3. *There exists a function* $\vartheta(n) \to \infty$ *such that if* $0 < k \le \binom{h}{2} < \vartheta(n)$, *then for* $e = \lfloor \frac{1}{4}n^2 \rfloor + k$,

$$\chi_S(n, e, C_5) = (h+1)\left\lfloor \frac{n}{2} \right\rfloor + k + O(\sqrt{k}).$$

We have several further results in this area. Altogether, mostly we restrict ourselves here to the simplest versions of our results.

This lecture is partly based on a manuscript of Erdős and Simonovits [3] from the late 1980's.

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