04221 Abstracts Collection
Robust and Approximative Algorithms on Particular Graph Classes
— Dagstuhl Seminar —

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Abstract. From 23.05.04 to 28.05.04, the Dagstuhl Seminar 04221 "Robust and Approximative Algorithms on Particular Graph Classes" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Graph structure, graph classes, graph algorithms, robust algorithms, approximation

04221 Summary – Robust and Approximative Algorithms on Particular Graph Classes

The aim of this seminar was to bring together experts working on robust as well as on approximative graph algorithms. Given the fast advances in various areas of graph algorithms on particular graph classes that we have witnessed in the past few years, we believe that it was very important to offer researchers in these areas a forum for the exchange of ideas in the relaxed workshop-like atmosphere that Dagstuhl always offers.

There was a strong interaction and healthy exchange of ideas which resulted in successful applications of robust and approximative graph algorithms; in particular, the seminar had the following aims:

* discussing new graph classes where the recognition complexity of a graph class is harder than solving certain basic graph problems on the class;

* new structural insights by studying the modular and homogeneous decomposition as well as treewidth and clique-width of important graph classes, and the application of these results to the design of robust graph algorithms;
* parameterized complexity and its influence to the design of efficient approximative algorithms;
* solving graph problems approximatively by using (non-)linear programming for graph classes where the problems can be solved in polynomial time but the time bound is poor (e.g. network design problems, Maximum Independent Set for perfect graphs).

The most outstanding result of the discussions during the seminar was the proof of the Seese conjecture by combining results of Courcelle and Sang-il Oum.

As always, Schloss Dagstuhl and its stuff provided a very convenient and stimulating environment. The organizers wish to thank all those who helped to make the seminar a fruitful research experience.

Joint work of: Brandstädt, A.; Corneil, D.; Jansen, K.; Spinrad, J.

Recognizing Chordal Probe Graphs

Anne Berry (Université Blaise Pascal - Aubiere, F)

A graph G=(V,E) is chordal probe if V can be partitioned into a set P of probes and an independent set N of non-probes so that it is possible to add edges between non-probes to obtain a triangulation of G.

We show that when the partition into probes and non-probes is given, we can solve the recognition problem on the more general class of 'N-T' graphs, where N is not necessarily a stable set, in O(|P|m) time, and produce as certificate a minimal triangulation in O(nm) time.

When the partition is not given, we show that chordal probe graphs belong to a larger class we introduce as 'cycle-bicolorable graphs', which are bicolorable in such a fashion that colors alternate on every chordless cycle of length at least 4. Cycle-bicolorable graphs are perfect and can be recognized in $O(n^4)$ time.

In an arbitrary graph, such chordless cycles can be grouped together into equivalence classes of vertices, which defines a new hole-and-antihole-preserving graph decomposition with no overlap.

When G is cycle-bicolorable, it is easy to determine whether it is also chordal probe, by a constructive method which greedily labels the vertices into probes and non-probes at no extra cost.

Keywords: Chordal probe graphs, interval probe graphs, triangulations, cycle-bicolorable graphs.

Joint work of: Berry, Anne; Lipsteyn, Marina ; Golumbic, Martin C.

On treewidth lower bounds

Hans L. Bodlaender (Utrecht University, NL)

The talk surveys some recent work on lower bounds for treewidth. It tells about some experimental work, and some more theoretical results on a lower bound based on maximum cardinality search.

Keywords: Treewidth, maximum cardinality search, lower bound, degeneracy, contraction

Query efficient implementation of graphs of bounded clique-width ; On a conjecture by D. Seese.

Bruno Courcelle (LaBRI - Bordeaux, F)

The first part of the talk is based on an article entitled "Query efficient implementation of graphs of bounded clique-width" (with R. Vanicat) Discrete Applied Mathematics 131 (2003) 129 - 150.

It comes out of a previous Dagstuhl seminar in 1999, where J. Spinrad asked some questions on implicit graph representation. This article shows that, given a graph property P(x1, ., xk) expressible in monadic second-order logic, where x1, ., xk denote vertices, a graph with n vertices and clique-width at most p where p is fixed, can be implemented with a piece of information I (u) of size O(log(n)) attached to each vertex u of G such that, for all vertices x1, ., xk of G, one can decide whether P(x1, ., xk) holds in time O(log(n)) by using only I(x1), ., I(xk). The preprocessing can be done in time O(n log(n)). One can do a similar thing for monadic second-order optimization function like distance.

The second part of the talk is based on a submitted paper :"The Monadic Second-Order Logic of Graphs XV: On a Conjecture by D. Seese".

This conjecture states that if a set of graphs has a decidable monadic second-order theory, then it is the image of a set of trees under a transformation defined by monadic second-order formulas. We prove that the general case of this conjecture is equivalent to the particular cases of directed graphs, partial orders and comparability graphs. We present some tools to prove the conjecture for line graphs and for interval graphs. We make an essential use of prime graphs, of comparability graphs and of characterizations of graph classes by forbidden induced subgraphs. By using a counting argument, we show the intrinsic limits of these methods to handle this conjecture.

Parallel Algorithm for Sandwiched Minimal Elimination Ordering

Elias Dahlhaus (DB Systems GmbH - Frankfurt, D)

The results came up during this workshop. The essential idea of the algorithm is that the substrars of a vertex ordered graph can be computed in polylogarithmic time with O(nm) processors. Herewith we get a collection of minimal separators that do not cross. Finally we have to extend the collection of minimal separators to a maximal collection of minimal separators in parallel. Here the parallel algorithm of Dahlhaus and Karpinski for computing a minimal fill-in in parallel helps. The overall processor number is O(nm). The time is $O(log^2n)$ on a CRCW-PRAM.

Joint work of: Dahlhaus, Elias; Berry, Anne; Simonet, G.; Hegerness, Pinar

Joint Base Station Scheduling

Thomas Erlebach (University of Leicester, GB)

Consider a scenario where base stations need to send data to wireless users. Transmitting data from a base station to a user takes one round. A user can receive the data from any of the base stations in one round. If base station b transmits to user u in a round, no other user in distance at most |b-u| from b can receive data in the same round. The goal is to minimize the number of rounds until all users have their data.

We call this problem the Joint Base Station Scheduling Problem (JBS) and consider it on the line (1D-JBS) and in the plane (2D-JBS).

For 1D-JBS, we give a 2-approximation algorithm and polynomial optimal algorithms for special cases. We model transmissions from base stations to users as arrows (intervals with a distinguished endpoint) and show that their conflict graphs, which we call arrow graphs, are a subclass of perfect graphs. (Arrow graphs are graphs whose vertices are arrows and where two arrows are adjacent if and only if the head of one arrow is contained in the other.)

For 2D-JBS, we prove NP-hardness and show that some natural greedy heuristics cannot achieve approximation ratio better than O(log n), where n is the number of users.

Note: Several interesting properties of arrow graphs have been observed by colleagues attending this seminar including Jeremy Spinrad, Ross McConnell, R. Sritharan and Ekki Köhler. In particular, they have observed that arrow graphs are a subclass of PI graphs, which are in turn a subclass of trapezoid graphs and thus of co-comparability graphs.

Keywords: Arrow graph, wireless, approximation algorithm

Joint work of: Erlebach, Thomas; Jacob, Riko; Mihalak, Matus; Nunkesser, Marc; Szabo, Gabor; Widmayer, Peter

The List Partition Problem for Graphs

Elaine M. Eschen (West Virginia Univ. - Morgantown, USA)

The k-partition problem is: Given a graph G and a positive integer k, partition the vertices of G into at most k parts $A_1, A_2, ..., A_k$, where it may be specified that A_i induce a stable set, a clique, or an arbitrary subgraph, and pairs A_i, A_j (i not equal to j) be completely non-adjacent, completely adjacent, or arbitrarily adjacent. The list k-partition problem generalizes the k-partition problem by specifying for each vertex x a list L(x) of parts in which it is allowed to be placed. Many well-known graph problems can be formulated as list k-partition problems: e.g. 3-colourability, clique cutset,stable cutset, homogeneous set, skew partition, and 2-clique cutset.

We classify, with the exception of two polynomially equivalent problems, each list 4-partition problem as either solvable in polynomial time or NP-complete. In doing so, we provide polynomial-time algorithms for many problems whose polynomial-time solvability was open, including the list 2-clique cutset problem. This also allows us to classify each list generalized 2-clique cutset problem and list generalized skew partition problem as solvable in polynomial time or NP-complete.

Keywords: Graph partition, list partition, complexity, algorithm

Joint work of: Eschen, Elaine M.; Cameron, Kathie; Hoang, Chinh; Sritharan, R.

Exact (exponential) algorithms to compute the treewidth

Dieter Kratsch (Université de Metz, F)

We present an algorithm to compute the treewidth of any graph on n vertices in time $O(poly(n)1.9601^n)$.

The algorithm can be seen as a modification of an algorithm of Bouchitte and Todinca. The running time analysis is based on combinatorial proofs for exponential upper bounds on the number of minimal separators and the number of potential maximal cliques in an n-vertex graph.

Keywords: Exponential algorithms, NP-complete problems, graphs, treewidth

Joint work of: Fomin, Fedor; Kratsch, Dieter; Todinca, Ioan

A certifying Algorithm for the Consecutive-ONES Property

Ross McConnell (Colorado State University, USA)

A certifying algorithm is one that returns, with each output, an easily-checked certificate, or proof, that the output has not been compromised by a bug. For example, to test whether a graph is planar can return a planar embedding to prove that it is, or point out a a Kuratowski subgraph if it is not.

Such certificates are highly desirable for ensuring software reliability. They sidestep the intractable issue of whether an implementation is correct by giving a simple proof of the correctness of each individual output.

We give a certifying algorithm for determining whether a 0-1 matrix has the consecutive-ones property. A matrix has this property if its columns can be permuted so that, in each row, the ones form a consecutive block. In the process, we show that the well-known PQ tree is a special case of a substitution decomposition of arbitrary 0-1 matrices.

Keywords: Certifying algorithms, PQ trees, consecutive-ones property, interval graphs

Error Compensation in Leaf Root Problems

Rolf Niedermeier (Universität Jena, D)

Nishimura, Ragde, and Thilikos (J. Alg. 2002) introduced the k-Leaf Root problem as a particular case of graph power problems.

Here, we study "error correction" versions of k-Leaf Root—that is, for instance, adding or deleting at most l edges to generate a graph that has a k-leaf root.

We provide several NP-completeness results in this context, and we show that the NP-complete Closest 3-Leaf Root problem (the error correction version of 3-Leaf Root) is fixed-parameter tractable with respect to the number of edge modifications or vertex deletions in the given graph.

Thus, we provide the seemingly first nontrivial positive algorithmic result in the field of error compensation for leaf root problems with $k > 2$.

To this end, as a result of independent interest, we develop a forbidden subgraph characterization of graphs with 3-leaf roots.

Keywords: NP-completeness, fixed-parameter tractability, graph algorithms, graph modification, graph power, leaf root, forbidden subgraph characterization

Joint work of: Niedermeier, Rolf; Dom, Michael; Guo, Jiong; Hüffner, Falk

Replace Clique-width With Rank-width

Sang-il Oum (Princeton University, USA)

The definitions of tree-width and branch-width of graphs are very symmetric and easy to find structures of graphs of bounded tree-width and/or branch-width. But, it's still open to find a structure of graphs of bounded clique-width. I believe the reason is that the definition of clique-width makes it hard to find nice characterizations of graphs of bounded clique-width.

In this talk, a new width-parameter of a graph, rank-width, is introduced. And several recent results will be presented:

(1) Clique-width and rank-width are compatible; if one is bounded, another is bounded.

(2) There is a fixed-parameter-tractable algorithm to output either rank-width>k or rank-width<=f(k).

(3) Vertex-minor relation, extending induced subgraph relation and preserving rank-width<=k property.

(4) A list of excluded vertex-minors of being rank-width<=k is finite.

(5) Any class of graphs, each of rank-width <=k, is well-quasi-ordered by the vertex-minor relation.

(6) Structural property of bipartite graphs of large rank-width(or clique-width).

Some of the work are coworks with Paul Seymour.

Keywords: Clique-width; rank-width; branch-width; graph minor; vertex-minor; isotropic system; local complementation; fixed-parameter-tractable; well-quasi-ordering

The Relative Clique-Width of a Graph

Dieter B. Rautenbach (Universität Bonn, D)

The tree-width of graphs is a well-studied notion the importance of which is partly due to the fact that many hard algorithmic problems can be solved efficiently when restricted to graphs of bounded tree-width.

The same is true for the clique-width which is a relatively young notion generalizing tree-width in the sense that graphs of bounded tree-width have bounded clique-width.

Whereas tree-decompositions that are used to define tree-width are a very intuitive and easily visualizable way to represent the global structure of a graph, the clique-width is much harder to grasp intuitively.

To better understand the nature of the clique-width, we introduce the notion of relative clique-width and study two algorithmical problems related to it.

In conjunction, these problems would allow to determine the clique-width.

For one of the problems, which is to determine the relative clique-width, we propose a polynomial-time factor 2 approximation algorithm and also show an exact solution in a natural special case.

The study of the other problem, which is left open in the paper, has brought us to an alternative and transparent proof of the known fact that graphs of bounded tree-width have bounded clique-width.

Keywords: Clique-width; tree-width; tree-decompositions; chromatic number; coloring; approximation algorithm

Joint work of: Rautenbach, Dieter B.; Lozin, Vadim

ISGCI - Information System on Graph Classes and their Inclusions

Natalia Ryabova (Universität Rostock, D)

ISGCI - Information System on Graph Classes and their Inclusions

http://wwwteo.informatik.uni-rostock.de/isgci

ISGCI is a Java applet that helps to research what's known about particular graph classes.

For a chosen graph class ISGCI provides: - definition of this graph class: If it is defined by a set of forbidden induced subgraphs, ISGCI provides links to drawings of these subgraphs; - lists of subclasses, superclasses and equivalent classes of this graph class; - list of problems on this graph class and their complexity; - literature references on this graph class and the complexity of problems on it.

With ISGCI users can: - find the relation between two graph classes (subclass/superclass/equivalent class/none of these relations: In the latter case ISGCI finds maximal common subclasses and minimal common superclasses); - see literature references on inclusions between graph classes; - draw clear inclusion diagrams; - colour a diagram: Every class gets a colour dependent on the complexity of a chosen problem: Green for polynomial, red for NP-complete; - export a diagram to Postscript for printing.

At the moment there are 799 classes and 60355 inclusions in the database of ISGCI, and it's growing continuously.

Keywords: Graph class, inclusions, research supporting system

Joint work of: Brandstädt, A.; Le, V.B.; Szymczak, T.; Siegemund, F.;De Ridder, H.N.; Knorr, S.; Rzehak, M.; Mowitz, M.; Ryabova, N.

Algorithms for biclique separable graphs

R. Sritharan (University of Dayton, USA)

A biclique is the disjoint union of two cliques. Graph G is biclique separable if it has no induced cycles of length five or more, and every induced subgraph of G that is not a clique has a cutset that induces a clique or a biclique (thus, generalizing chordal graphs). We show that recognition, and computation of minimum coloring and largest clique can be done efficiently for the class of biclique separable graphs.

Joint work of: Sritharan, R.; Eschen, Elaine; Hoang, Chinh; Petrick, Mark

Constructions of Sparse Asymmetric Connectors with Number Theoretic Methods

Anand Srivastav (Universität Kiel, D)

We consider the problem of connecting a set I of n inputs to a set O of N outputs (n<=N) by as few edges as possible such that for every injective mapping f:I–>O there are n vertex disjoint paths from i to f(i) of length k for a given integer k.

We show by a probabilistic argument that an optimal (n,N)-connector has Theta(N) edges, if $n <= N^{(}.5 - c)$ for some c>0. Moreover, we give explicit constructions that need at most N*sqrt(3n/4)+2n* sqrt(3nN/4) edges for arbitrary choices of N and n.

Keywords: Connector, rearrangeable network, sparse switch, permuter, combinatorial number theory, restricted sums

Joint work of: Srivastav, Anand; Jaeger, Gerold; Baltz, Andreas

Self-Clique Graphs and Matrix Permutations

Jayme L. Szwarcfiter (Federal University - Rio de Janeiro, BR)

The clique graph of a graph is the intersection graph of its (maximal) cliques. A graph is self-clique when it is isomorphic with its clique graph, and is clique-Helly when its cliques satisfy the Helly property. We prove that a graph is clique-Helly and self-clique if and only if it admits a quasi-symmetric clique matrix, that is, a clique matrix whose families of row and column vectors are identical. We also give a characterization of such graphs in terms of vertex-clique duality.

We describe new classes of self-clique and 2-self-clique graphs. Further, we consider some problems on permuted matrices (matrices obtained by permuting the rows and/or columns of a given matrix). In particular, we prove that deciding whether a (0,1)-matrix admits a symmetric (quasi-symmetric) permuted matrix is graph (hypergraph) isomorphism complete.

Keywords: Clique graph, clique-Helly graph, computational complexity, permuted matrix, self-clique graph

Joint work of: Bondy, Adrian; Duran Guillermo; Lin, Min C; Szwarcfiter, Jayme L

Subgraph Isomorphism and Related Problems for Restricted Graph Classes

Gabriel Valiente (TU of Catalonia - Barcelona, E)

Subgraph isomorphism and related problems have practical applications in combinatorial pattern matching, pattern recognition, chemical structure search, computational molecular biology, and other areas of engineering and life sciences. One of the simplest graph classes on which subgraph isomorphism becomes polynomial-time solvable are trees. In this talk, a brief review of subgraph isomorphism and related problems (maximum common subgraph and minimum common supergraph under isomorphism, homeomorphism, and minor containment)on trees is given and the generalization of these problems to graphs of bounded tree-width is discussed.

Keywords: Subtree isomorphism, subtree homeomorphism, minor containment, largest common subtree, smallest common supertree, partial k-tree

On Normal Graphs and the Normal Graph Conjecture

Annegret Wagler (K. Zuse Zentrum Berlin, D)

Normal graphs are defined in terms of cross-intersecting set families and constitute a closure of perfect graphs by means of co-normal products (Körner 1973) and graph entropy (Cziszar et al. 1990).

Perfect graphs have been recently characterized as graphs without odd holes and odd antiholes (Strong Perfect Graph Theorem, Chudnovsky et al. 2002). Körner and de Simone observed that the odd holes and odd antiholes with at most 7 nodes are minimal not normal and conjectured, in analogy to the Strong Perfect Graph Theorem, that every graph without those three subgraphs is normal (Normal Graph Conjecture, Körner and de Simone 1999). We discuss several aspects of normal graphs w.r.t. this conjecture.

Keywords: Perfect graphs, normal graphs, normal graph conjecture