Third Workshop on Graph Classes, Optimization, and Width Parameters

GROW '07

University of Oregon, Eugene
October 18–20, 2007

Jan Kára, ed.

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Dear Participants,

Welcome to the Third Workshop on Graph Classes, Optimization, and Width Parameters. It is a continuation of what has become a series of meetings, the previous two having taken place in Barcelona in 2001 and Prague in 2005. From the historical perspective, this event is returning to the place of its origin: the workshop No. Zero was the Workshop on Efficient Algorithms on Partial k-Trees organized at University of Oregon in 1989, which resulted in the publication of a special volume of Discrete Applied Mathematics 54(2-3).

The Barcelona workshop resulted in a special volume of Discrete Applied Mathematics 145(2) published in 2005. Another special issue of that journal based on the Prague workshop is in the final stages of the editorial process and is scheduled to appear in early 2008. Accordingly, we plan to publish the papers related to this workshop as a special issue of Discrete Applied Mathematics. All participants will be welcome to submit a paper to this volume.

Eugene is known not only for its pleasant atmosphere of a university town, but also for the beauty of the surrounding nature. That includes numerous hiking opportunities as well as top quality wines that come from the vineyards of the lush Willamette Valley. We hope that you will enjoy samples of both, and that your time in Eugene will prove fruitful and enjoyable.

We would like to thank individuals and institutions that contributed to make this workshop possible - Jim Allen from University of Oregon for local organization, and Jan Kara from Charles University for help with editing this brochure. The following insitutions and grants contributed financially to the workshop: Department of Informatics, University of Bergen; Department of Computer and Information Science of the University of Oregon; DIMATIA (Charles University, Prague, and West Bohemia University, Pilsen).

Pinar Heggernes, Jan Kratochvíl and Andrzej Proskurowski

Workshop program

Wednesday

"Early Bird" hike with Honza

Thursday

9:30	**Opening and Problem session**	*Bowerman*
10:30	Coffee break	*Bowerman*
11:00	Y. Villanger: Improved Algorithms for the Feedback Vertex Set Problems	*Bowerman*
11:30	C. Papadopoulos: Characterizing and extracting min. cograph completions in linear time	*Bowerman*
12:00	Lunch	
14:00	R. Čada: On nuclear reactor core loading pattern optimization	*Bowerman*
14:30	T. Kaiser: Packing good paths	*Bowerman*
15:00	Break — moving to Deschutes Hall	
15:30	**J. A. Telle: Interval Graph Completion and P-Time Preprocessing**	*Deschutes Hall*
16:30	Coffee and problems	*Deschutes Hall*

Friday

9:30	**S. Oum: Introduction to rank-width**	*Law School*
10:30	Coffee break	*Law School*
11:00	B. Oporowski: The-width, tree-partition-width, congestion, and dilation	*Law School*
11:30	T. Kloks: Graph-Class Width I: Distance-hereditary– and Ptolemaic-Width	*Law School*
12:00	D. Obdržálek: Digraph connectivity measures and their applications	*Law School*
12:30	Lunch	
14:00	working session	*Law School*
15:00	Coffee break	*Law School*
15:30	M. Habib: Subset families and combinatorial decomposition theorems	*Law School*
16:00	M. Tedder: Simple, Linear-time Modular Decomposition	*Law School*
16:30	Break	
18:00	Banquet	*Gerlinger*

Saturday

9:30	**P. Hell: Characterizations and Dichotomies in Hom. Optimization**	*Law School*
10:30	Coffee break	*Law School*
11:00	D. Meister: Poly-time alg. for computing the bandwidth of bipartite permutation graphs	*Law School*
11:30	D. Lokshtanov: Analyzing the Greedy Heuristic for Cutwidth	*Law School*
12:00	Lunch	
14:00	L. Stewart: Overlap graphs	*Law School*
14:30	A. Brandstädt: On Leaf Powers	*Law School*
15:00	Coffee break	*Law School*
15:30	Working session	*Law School*
16:30	Closing	*Law School*

Sunday

"Survivor" hike with Andrzej

Abstracts

On Leaf Powers

Andreas Brandstädt
(joint work with Van Bang Le, R. Sritharan, Peter Wagner and Christian Hundt)

Motivated by phylogenetic trees which reconstruct the evolutionary history of a set of species or taxa, Nishimura, Ragde and Thilikos in 2002 introduced the notion of k-leaf power and k-leaf root: A tree T is a k-leaf root of a finite undirected graph $G = (V_G, E_G)$ if V_G is the set of leaves of T and for all vertex pairs $x, y \in V_G$, x and y are adjacent in G if and only if the distance of x and y in T is at most k. Then G is a k-leaf power. G is a leaf power if it is a k-leaf power for some k.

Quite obviously, leaf powers are chordal graphs, and a graph is a 2-leaf power if and only if it is the disjoint union of cliques or, equivalently, it is P_3-free. Moreover, leaf powers are strongly chordal but not vice versa.

Nishimura et al. gave (very complicated) polynomial time recognition algorithms for 3- and 4-leaf powers; the problem of characterizing and recognizing k-leaf powers is widely open for k larger than 5.

We give new characterizations of 3- and 4-leaf powers, consider a variant of k-leaf roots which we call (k, l)-leaf roots, and show that ptolemaic graphs and unit interval graphs are leaf powers; thus, leaf powers have unbounded clique-width.

On nuclear reactor core loading pattern optimization

Roman Čada

Nuclear fuel loading pattern optimization is a difficult and comple problem. A part of it consists in a replacement of burned fuel assemblies by fresh ones and a consequent arrangement of these in a reactor zone under certain (e.g. safety) conditions.

We will review mathematical methods and a necessary physical background used for solving this problem with respect to their application in the Athena code. In particular we will focus on aspects related to combinatorial optimization.

Subset families and combinatorial decomposition theorems

Michel Habib
(joint work with Binh-Minh Bui Xuan)

Many combinatorial decompositions can be associated with subsets families having a kind of canonical tree representation, as for example for the modular or split decomposition of graphs.

We propose such tree representation for a union-difference subset family (i.e. family closed under union and difference of overlapping elements). We apply this framework to a new graph decomposition.

Characterizations and Dichotomies in Homomorphism Optimization (Invited talk)

Pavol Hell

I will describe the role of structural characterizations of graph classes in obtaining complexity classifications for homomorphism problems. The emphasis will be on list homomorphism and minimum cost homomorphism problems, where chordal graphs, interval graphs and bigraphs, proper interval graphs and bigraphs, as well as circular arc graphs play important roles. A feature of particular interest is what classes of digraphs arise in a similar manner.

Packing good paths

Tomáš Kaiser

Let G be a graph and A a set of its vertices. An A-path is a path with ends in A and all internal vertices outside A. A classical result of Gallai gives a min-max relation for the maximum number of disjoint A-paths in a graph. This was recently extended by Chudnovsky et al. to nonzero A-paths in graphs whose edges are labelled by group elements. A further extension, due to Pap, concerns so-called non-returning A-paths in permutation-labelled graphs. We give an overview of these results and present a generalization to an abstract scheme, where the paths to be packed are from a given set of "good" paths satisfying a certain axiom. Its connection to Mader matroids and some related questions will also be discussed.

Graph-Class Width I: Distance-hereditary– and Ptolemaic-Width

Ton Kloks

In this talk we introduce the following graph-parameter: Let $\mathcal{G}$ be a class of graphs. A graph G has *$\mathcal{G}$-width k* if it has k independent sets $\mathbb{N}_1, \ldots, \mathbb{N}_k$ such that G can be embedded into a graph $\bar{G} \in \mathcal{G}$ such that each edge in $\bar{G}$ which is not an edge in G has both its endvertices in some common $\mathbb{N}_i$.

If a graph G has $\mathcal{G}$-width at most k, then we call G a *k-probe graph of $\mathcal{G}$*. We call a 1-probe graph (of some class) also a *probe graph*.

It turns out that many of these parameters, e.g. complete-width, cograph-width, chordal-width, distance-hereditary-width, ptolemaic-width, etc. are NP-complete to compute. We focus on the fixed-parameter tractability. We focus our attention on the cases where $\mathcal{G}$ is the class of ptolemaic graphs and the class of distance-hereditary graphs. Graphs with distance-hereditary-width at most k have rankwidth at most 2^k. Therefore it is of interest to study the computational complexity of distance-hereditary-width. We show that it is fixed-parameter tractable. Ptolemaic graphs are the distance-hereditary graphs that are chordal. We show that ptolemaic-width is fixed-parameter tractable. Unfortunately, the constants involved in these FPT-algorithms are out of bounds; i.e., these algorithms are "of little practical importance". We show that there exists a more practical algorithm that recognizes whether a graph is a 1-probe graph of a ptolemaic graph and that finds an embedding if that is the case.

Analyzing the Greedy Heuristic for Cutwidth

Daniel Lokshtanov
(joint work with Pinar Heggernes, Rodica Mihai, and Charis Papadopoulos)

In this paper we study the *Cutwidth Minimization Problem* when the input is restricted to certain graph classes. As our main result we show that the most natural greedy heuristic for computing the cutwidth of a graph in fact always produces optimal layouts if the input is a treshold graph. To complement this result we show that this heuristic fails when the input is restricted to the trivially perfect graphs, and that the problem is NP-complete on split graphs. The Cutwidth Minimization Problem was first used as a theoretical model for computing the number of channels in an optimal layout of a circuit. More recent applications of the problem include network reliability, automatic graph drawing, information retrieval, and as a subroutine for the cutting plane algorithm to solve the Travelling Salesman Problem.

This work is supported by the Research Council of Norway through grant 166429/V30.

A polynomial-time algorithm for computing the bandwidth of bipartite permutation graphs

Daniel Meister
(joint work with Pinar Heggernes and Dieter Kratsch)

We give the first polynomial-time algorithm that computes the bandwidth of bipartite permutation graphs. Bandwidth is an NP-complete graph layout problem that is notorious for its difficulty even on small graph classes. For example, it remains NP-complete on caterpillars of hair length at most 3, a special subclass of trees. Much attention has been given to designing approximation algorithms for computing the bandwidth, as it is NP-hard to approximate the bandwidth of general graphs with a constant factor guarantee. The problem is considered important even for approximation on restricted classes, with several distinguished results in this direction, some of which have appeared at previous FOCS and SODA conferences. Prior to our work, polynomial-time algorithms for exact computation of bandwidth were known only for caterpillars of hair length at most 2, chain graphs, cographs, and most interestingly, interval graphs.

Digraph connectivity measures and their applications

Jan Obdržálek

Graph connectivity measures like tree-width have been a great success. They are widely used in many different areas of mathematics and computer science. On the other hand, these measures are usually defined for undirected graphs only. However many applications are based on directed graphs which, while often quite simple (e.g. directed acyclic graphs), have high tree-width when their underlying undirected graphs are considered. In the last two years new connectivity measures for directed graphs have been defined - e.g. DAG-width and Kelly-width. In this talk I will present some of these measures, explain the relationship between them, and present the most recent results. I will also look at some applications where the use of directed graph measures is beneficial.

The-width, tree-partition-width, congestion, and dilation

Bogdan Oporowski
(joint work with Guoli Ding)

In the talk, I will discuss several parameters that provide various measures of how closely a graph resembles a tree. These parameters are tree-width, tree-partition-width, dilation, and congestion, the last two of which are respective tree analogs of band-width and cut-width. The main result asserts that dilation and congestion are tied, that is, if one of them is bounded for a class of graphs, then so is the other. The proof involves both tree-width and tree-partition-width, and produces a corollary stating that all four parameters are tied for every class of graph with bounded maximum degree.

Introduction to rank-width (Invited talk)

Sang-il Oum

We will review definitions of rank-width, its relations to vertex-minors and tangles, and known theorems / algorithms. Then we will discuss two "toy" problems based on those relations.

1. We will show that rank-width is smaller than or equal to branch-width (unless the graph has no edges).
2. Then we will discuss the lower bound on the rank-width of the grid.

Characterizing and extracting minimal cograph completions in linear time

Charis Papadopoulos
(joint work with Daniel Lokshtanov and Federico Mancini)

A cograph completion of an arbitrary graph G is a cograph supergraph of G on the same vertex set. Such a completion is called minimal if the set of edges added to G is inclusion minimal. If a cograph completion H of G is not minimal then H contains a minimal cograph completion H' as a subgraph. Computing H' from G and H is referred to as extracting a minimal cograph completion. In this paper we characterize minimal cograph completions, and we give a linear-time algorithm for extracting a minimal cograph completion from any given cograph completion of G.

Overlap graphs

Lorna Stewart

Two sets overlap if they intersect and neither is contained in the other. The overlap graph of a set of sets contains one vertex for each set, and an edge between two vertices if and only if the corresponding sets overlap. We discuss some properties of overlap graphs in general and of the overlap graphs of subtrees of a tree.

Simple, Linear-time Modular Decomposition

Marc Tedder

Modular decomposition is fundamental for many important problems in algorithmic graph theory including transitive orientation, the recognition of several classes of graphs, and certain combinatorial optimization problems. Accordingly, there has been a drive towards a practical, linear-time algorithm for the problem. Despite considerable effort, such an algorithm has remained elusive. The linear-time algorithms to date are impractical and of mainly theoretical interest. In this talk we present the first simple, linear-time algorithm to compute the modular decomposition tree of an undirected graph. The breakthrough comes by combining the best elements of two different approaches to the problem.

Interval Graph Completion and Polynomial-Time Preprocessing (Invited talk)

Jan Arne Telle

This talk will start by arguing that the complexity class FPT can be used to capture the notion of polynomial-time preprocessing to reduce input size. This is followed by an FPT algorithm with runtime $O(n^{2k}n^3m)$ for the following NP-complete problem [GT35 in Garey&Johnson]: Given an arbitrary graph G on n vertices and m edges, can we obtain an interval graph by adding at most k edges to G? The given algorithm answers a question first posed by Kaplan, Shamir and Tarjan in 1994.

Improved Algorithms for the Feedback Vertex Set Problems

Yngve Villanger

We present improved parameterized algorithms for the Feedback Vertex Set problem on both unweighted and weighted graphs. Both algorithms run in time $O(5^k k n^2)$. The algorithms construct a feedback vertex set of size bounded by k (in the weighted case this set is of minimum weight among the feedback vertex set of size at most k) in a given graph G, or reports that no such a feedback vertex set exists in G.

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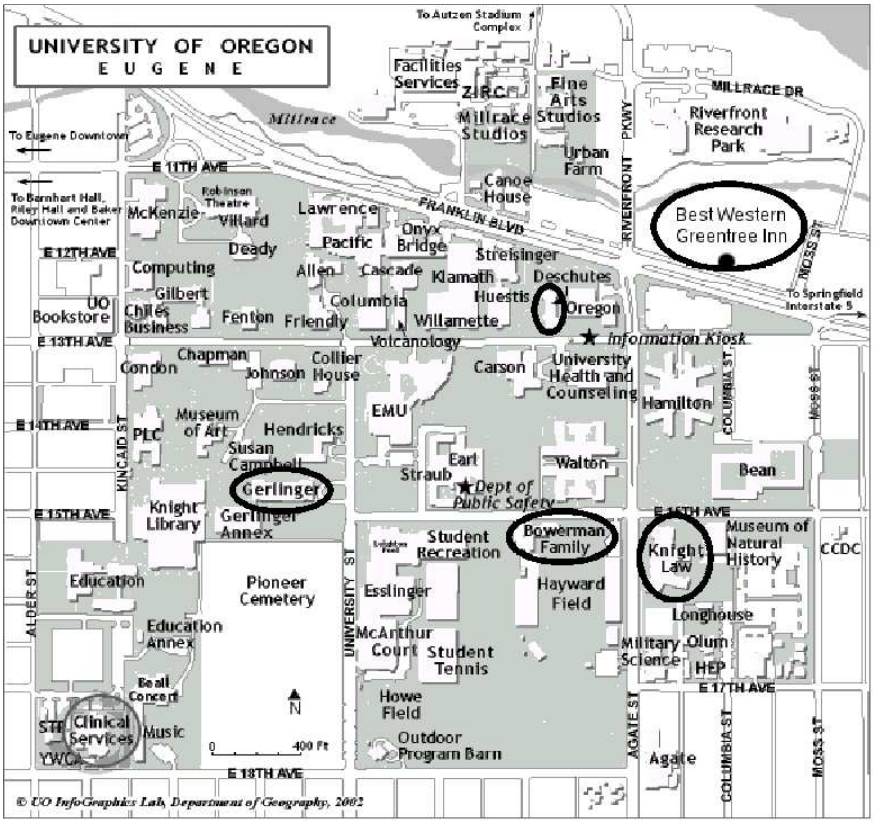
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Other useful information

The motel most of the participants are staying at is:

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In cases of emergency during business hours, you can call Computer Information and Science Department 531-346-4408 (fax number is 541-464-5373). Or – in extreme cases – Andrzej's cell phone 541-554-5931.