ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ • ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING • UNIVERSITY OF IOANNINA

ΠΑΡΟΥΣΙΑΣΗ
ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ

ΗΜΕΡΟΜΗΝΙΑ: Τρίτη, 9 Ιουλίου 2024

ΩΡΑ: 10:00

ΑΙΘΟΥΣΑ: Αίθουσα Σεμιναρίων, ΤΜΗΥΠ

ΟΜΙΛΗΤΗΣ: **Διονύσιος Κεφαλληνός**

Θ έ μ α

« Algorithm Design and Engineering for Graph Connectivity Problems »

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Π ε ρ ί λ η ψ η

This dissertation deals with topics related to some notions of graph connectivity in directed graphs and mixed graphs. We present efficient implementations and empirical studies of important algorithms for basic connectivity problems in directed graphs. Moreover, we propose efficient methods for speeding up these algorithms in practice, which improved their execution times by one to two orders of magnitude. Finally, we provide new linear-time algorithms for related connectivity problems in mixed graphs.

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Firstly, we provide an experimental study of algorithms for computing the edge connectivity λ of a directed graph G efficiently in practice. Computing the edge connectivity of a graph is a classical subject in graph theory, since it is an important notion in several application areas. We presented the first efficient implementations of Gabow's algorithm which runs in $O(\lambda m \log n)$ time, for a directed graph with n vertices and m edge, and is based on matroid intersection and packing spanning trees, as well as algorithms based on recent "local search" algorithms for minimum-cut, of complexity $O(\lambda^2 m \text{"polylog"} n)$. Also, we proposed practical methods for speeding up these algorithms. In the experimental study, the efficiency of the various algorithms was compared on real graphs, taken from various application areas, as well as on synthetic graphs, aiming to highlight the advantages and disadvantages of each technique.

Then we studied the related problem of packing arborescences. We explored the design space of efficient algorithms and conducted a thorough empirical study to highlight the merits and weaknesses of each technique. In particular, we presented efficient implementations of Gabow's arborescence packing algorithm of complexity $O(k^2 n^2)$, Tarjan's algorithm of complexity $O(k^2 m^2)$, and the algorithm of Tong and Lowler of complexity $O(k^2 mn)$, where k is the maximum number of arborescences in a packing. In addition, we proposed a simple but very efficient method that significantly improves the running time of Gabow's algorithm in practice. In our experimental study, the performance of the various algorithms was compared on real-world taken from a wide range of applications, as well as on synthetic graphs.

Finally, we considered some orientation problems in mixed graphs related to the concept of 2-edge strong connectivity. A mixed graph G is a graph that consists of both undirected and directed edges. An orientation of G is formed by orienting all the undirected edges of G, i.e., converting each undirected edge $\{u,v\}$ into a directed edge that is either (u,v) or (v,u). Many mixed or undirected graph orientation problems have been studied in the literature, depending on the properties we wish to have. Our main result was to provide a linear time algorithm for the following problem. Given a mixed graph G, we wish to compute its maximal sets of vertices $C_1,C_2,\dots,C_k$ with the property that by removing any edge e from G (directed or undirected), there is an orientation R_i of $G \setminus e$ such that all vertices of C_i are strongly connected in R_i. This problem is related to 2-edge strong connectivity, since if G contains only directed edges, then every set C_i corresponds to a 2-edge strong component of G.

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