

Berlin, 17/8/2017

Referee report on the doctoral thesis “Structural Properties of Graphs and Efficient Algorithms: Problems Between Parameters” by Dušan Knop

The thesis of Dušan Knop studies several NP-hard graph problems from the viewpoint of parameterized complexity analysis. A particular aspect of his work is to study graph parameters that relate to sparse as well as to dense graphs. The work, organized into four main chapters, is based on four previously published articles, three of them having already appeared in peer-reviewed, competitive conference proceedings.

The work is well motivated and at the edge of time of current scientific research. The four main problems studied (Length-Bounded Cuts, Target Set Selection, Distance-Constrained Labeling and Uniform Channel Assignment, Partitioning into Induced Subgraphs) all appear in the scientific literature and have been studied by other researchers as well. A particular feature of this doctoral thesis is to present new (parameterized) views on these natural graph problems, each time providing novel and nontrivial insights, enriching our knowledge base for all these problems.

Next, I will briefly address the various chapters of the thesis and make some specific comments.

The chapter “Introduction” in roughly two pages briefly motivates and surveys the contributions of the thesis.

Chapter 1 introduces the framework of parameterized complexity analysis. In particular, it defines the central graph parameters used throughout the work.

Chapter 2 studies length-bounded cuts in sparse graphs. Roughly speaking, the task here is to interdict “short” paths between two designated vertices by deleting a minimum number of edges. Exploiting parameters such as treewidth, treedepth, or pathwidth, both parameterized tractability and intractability results are presented. The corresponding algorithms and reductions use clever ideas and gadgets. No serious flaws could be spotted. At some points, the presentation is somewhat disruptive, lacking connecting and motivating sentences between different contributions of this chapter. Some proofs are quite dense (short), though; so there is some space to improve on readability. A concluding section is missing for this section, but it might have been helpful to discuss the results in retrospective.

A few technical remarks: In Lemma 9, the union G of G_1 and G_2 is not clear. In the proof of Theorem 4: there is a typo “>=”; moreover $3(k+1)^2$ is at most $6k^2$ only for $k > 2$. In the reduction (2.4.3), one should finally say that all s and t in the highlands are identified

with s and t . For the no-poly-kernel result, a direct AND-composition following the same idea as presented for (D)LBC should also work; and would be more direct...

Chapter 3 studies the Target Set Selection problem in dense graphs. This is motivated by applications in social network analysis and related to analyzing the spread of disease and rumors and also by viral marketing—in the thesis it is somehow wrongly attributed to the field of Computational Social Choice, which mainly deals with voting-like problems. Roughly speaking, in Target Set Selection one seeks for a minimum set of vertices that may “activate” all other vertices (all of these have some activation threshold that has to be reached and gives the number of neighbors that need to be activated on order to get activated itself). The main strength of this chapter lies in innovative hardness reductions. Again, no significant technical flaws could be spotted and the results are new and of clear interest. However, the motivation given is very short and somewhat incomplete also with respect to literature. For instance, as to parameterized inapproximability results, the following references should be relevant: Bazgan, Chopin, Nichterlein, Sikora: “Parameterized approximability of maximizing the spread of influence in networks.” *Journal of Discrete Algorithms*, 2014. Bazgan, Chopin, Nichterlein, Sikora: “Parameterized Inapproximability of Target Set Selection and Generalizations.” *Computability*, 2014.

Further technical remarks: On page 34 one reads: “A general lower bound on the number of selected vertices under majority constraints is $|V|/2$ [1].” Here the ‘lower bound’ should be ‘upper bound’. Consider for example a path where a target set of size one exists. Figure 3.2 is a bit cryptic. ILP formulation on page 41: You need to add on the right-hand side the summand x_C in case that the vertices of type C induce a clique. If C is a clique, then the x_C many vertices of C that are in the target set will also influence the remaining vertices in C before C is activated! In the Conclusion, it is written “The presented results give new methods for showing $W[1]$ -hardness result.” What is a new method here? I did not see any general approach—‘just’ clever constructions.

Chapter 4 studies distance constrained labeling and closely related channel assignment problems. While NP-hardness results are obtained even if the cliquewidth (equivalently, NLC-width) of the given graph is constant, fixed-parameter tractability is achieved for the parameter neighborhood diversity (the latter being the main result). The writing of this chapter is quite dense and could benefit from more motivation.

Few technical remarks: Where is Figure 4.1 referenced in the text? The caption is not very clear. What is the statement here?

Chapter 5 studies the problem to partition a given graph into a number of isomorphic induced subgraphs (as specified by an input pattern graph H). Using the parameters modular width and neighborhood diversity, some fixed-parameter tractability results are developed. In this context, tools such as Monadic Second-Order Logic (and Courcelle’s theorem) and Integer Linear Programming are used.

The overall conclusion of less than half a page very briefly points to the main findings of the work and names a few challenges for future research.

In summary, the thesis presents several strong scientific results (partially already published at peer-reviewed international conferences) on a diverse set of natural graph problems. It may have impact in terms of stimulating further theoretical studies.

The thesis is well structured and follows an appealing agenda. The achieved results are important and new. The thesis proves the author's ability to perform creative scientific work at a high level. No significant technical errors could be spotted.

My main but somewhat significant criticism is the quality of writing. There are numerous typos, grammatical errors (in particular with respect to missing articles), and even broken sentences (e.g., "There are two major examples of this parameter use either the parameter of value k expresses that after removal of k vertices the input graph is turned in a graph belonging to a class of graphs on which the problem under consideration becomes trivial (polynomial time solvable) or it may be viewed as the distance from guarantee, as for example the guarantee given by rounding a relaxation of the integer linear program [60].") The readability further suffers from a below-average effort in providing motivating texts (e.g. applications, examples, etc.) and a lack of making the train of thought visible again and again. In this sense, the writing is very dense (like for conferences) but sometimes there is quite something missing in order to make the various chapters into something like a decent journal article. For the final version of the thesis a thorough proofreading is warmly recommended. This having been said, however, it must be clearly pointed out that in terms of scientific achievements and results this is a strong thesis.

Overall Recommendation. Aside from my criticism concerning the presentation style (which may easily be improved) this is a very good thesis containing numerous theoretically appealing results. The overall contribution is both wide and deep enough to clearly merit the qualification as a PhD thesis. The work makes a significant contribution to current research in parameterized algorithmics and complexity analysis. Without hesitation, I consider this thesis as a clear "pass" and recommend to accept it.



Prof. Dr. Rolf Niedermeier