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Review of Aryan Kumar's Bachelor Thesis: "Performance Comparison of ILP versus Logical Solvers on Bribery-type Problems"

Aryan Kumar's thesis deals with evaluating two approaches for solving the *Bribery in Society Graphs (BSG)* problem. Briefly put, in this problem we are given an election where voters are partitioned into certain types, a preferred candidate p, a budget B, and a voting rule $\mathcal{R}$. We ask if it is possible to introduce changes into the votes that altogether cost at most B, so that p becomes a winner. An additional problem is that the voters form a society graph: Voters of certain types are connected and if voters from some type t see that among the voters that they are connected to, a majority represents some other type t', then the voters from type t switch to type t'. This process runs until convergence and only then the election winner is determined. Originally, the BSG problem was studied in one of my papers and Aryan Kumar's thesis includes a thorough recollection of its definition and of the main results of this paper. This includes a description of an FPT algorithm for the problem based on ILP solving. The thesis also contains a new algorithm, albeit quite related to the ILP one, based on Presburger arithmetic (PrA).

The main part of the thesis (Chapter 4) includes a series of experiments evaluating the performance of ILP solvers and PrA solvers, as well as some approaches to encoding the problem. The first experiment regards two possible ways in which the task of optimizing the bribery cost could be encoded. The first approach is to rely on quantification mechanisms present in PrA and the second approach formulates the problem as asking if there is a bribery of at most a given cost B and then performing binary search on B. I find this experiment interesting, even if the result is disappointing in that quantification-based approach is notably worse. However, I think that Figure 4.2 could have been presented in a much better form. Indeed, it is never truly explained what various colors mean and what is the difference between the top and bottom parts of the figure. From what I understand, it would have been more informative if the bottom part were sorted with respect to the running time (separately for each optmization technique). This way we might not see the

same instance in the same spot, but we would get a much better idea regarding high-level performance comparison.

The reminder of Chaper 4 includes a series of experiments analyzing how the number of voters, the dimensionality of the problem, and other features affect the running times of various ILP and PrA solvers. While, sadly, ILP solvers turn out to be faster, the experiments are well-executed and appealing (the reason for "sadness" is that even the ILP solvers are not doing too well for the problem and it would have been great if PrA solvers could have come to the rescue). Occasionally, I felt that the sample sizes used in the experiments were to small (e.g., just five instances) but I can also see how this helped with evaluating numerous different settings.

Perhaps the biggest complaint I would have regarding the experiment is that the author does not really explain how he generated "random" data. Lack of such explanations typically means using the impartial culture assumption, i.e., choosing each possible preference order with the same probability and I suspect that this is what happened. Nonetheless, elections generated using the Mallows model, or the Polya-Eggenberger urn model, or whatever other distributions would also be "random" and so such things should be clarified.

A minor issue that I spotted was a claim that the simplex algorithm runs in polynomial time (p. 18). As far as I understand, there are instances where it makes exponentially many steps (even if such instances are not typical).

On the editorial and language level, the thesis is mostly of high quality, but there are occasional glitches. For example, Section 1.4 starts directly with a definition, which I consider to be a poor writing style; there always should be at least some sort of an opening paragraph or sentence. Typesetting of Chapter 2's title is a bit off (I would expect $\mathcal{R}$-BSG to be typeset using a bold face; similar issues appear in a few other section titles). My largest complaint regarding the formal side of the thesis is how the bibliography was prepared. The author has omitted most names of the authors and, instead, just listed them as, e.g., "Riccardo Cantinit et al.". I think this is inappropriate (although not critical). Also, for some reason the name of the author of paper [35] is typeset in upper case, while all other names are typeset using standard capitalization.

All in all, the thesis presents a very solid bit of work, especially taking into account that it was conducted by a bachelor student. The results are valuable and certainly improve our understanding of bribery in society graphs. The complaints I list above are not crucial and do not affect my very high evaluation of the thesis (I assign **grade 1).**

Best regards,
Piotr Faliszewski