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Review of the doctoral thesis
"Online Algorithms for Packet Scheduling"
by Mgr. Pavel Veselý

The presented doctoral thesis studies a number of problems in the area of online scheduling. In many applications we are faced with the task of making decisions on an ongoing basis without knowing what will happen in the future. The thesis starts with an excellent example to illustrate this. Suppose a company has a launch system which can launch one satellite into orbit each month. The company receives requests for launches which are associated with a specific profit and a deadline. If the company manages to launch the satellite by the given deadline, it will gain the associated profit. Otherwise it will not. Which satellite should the company launch each month? The challenge is to find the right trade off between launching low profit satellites with a deadline that is coming up soon and launching high profit satellites which have longer deadlines. If we knew that we will not get any more requests for launches in the future, it may be better to launch the low profit satellite. However, if we knew that we will get more requests for very profitable launches soon, it may be better to forgo the low profit launch in favor of being able to fit all the high profit ones into a limited time window.

Algorithm that make decisions like this without using any information about future requests are known as online algorithms. The typical goal in the design and formal theoretical analysis of such algorithms is to compare their performance (the total profit obtained) to the optimal profit that could have been achieved if we knew all future requests and would have made optimal decision based on this information. Specifically, the so-called competitive ratio of an online algorithm A measures the worst case ratio (i.e. assuming an input sequence of requests which maximizes this ratio) between the profit obtained by an optimal offline algorithm and the profit that online algorithm A achieves.

In this doctoral thesis, several new online algorithms for different online scheduling problems are presented and their competitive ratio is formally analyzed. The most significant result is an about 1.618-competitive online algorithm for bounded delay packet scheduling. This problem, which corresponds to the example first given in the thesis and summarized in the beginning of this report, was first introduced in 2001 and has been intensely studied since then. It was known that no deterministic online algorithm can be better than 1.618-competitive, but up to this point it was not known whether there is a deterministic online algorithm that achieves this competitive ratio. In a number of increasingly complex works the upper bound was improved from 2, over 1.939, to 1.854 and 1.828. No further improvement was made in over a decade. The result in this thesis finally resolves this long standing open question around a central problem of online scheduling.

Additional results are given for a semi-online variant of the problem. In this variant the online algorithm has a certain amount of lookahead, i.e., it can see ℓ steps into the future. As a positive result, an about 1.303-competitive deterministic online algorithm is given if the deadline is limited to two steps ahead of the release time of a request and $\ell = 1$. In addition, several lower bounds are given. The first is about 1.281 for deterministic online algorithms under the same conditions. The second generalizes this for larger values of ℓ, but the value of the lower bound decreases with growing ℓ. The third lower bound shows that no randomized algorithm can be better than 1.25-competitive for any fixed amount of lookahead. It is worth mentioning that the third lower bound is strictly stronger than the second lower bound for $\ell > 1$. Therefore, it is not entirely clear why the second lower bound was included separately in the thesis.

The last chapter of the thesis considers a slightly modified model: Packet Scheduling under Adversarial Jamming. Here a number of jobs of different sizes should be executed on a single machine. However, at some points in time, the machine has faults and any job that is executed at such a time will be aborted and any progress made so far towards completing the job is lost. The algorithm should attempt to maximize the sum of sizes of successfully completed jobs. Previous deterministic online algorithms relied on knowledge about the set of job sizes that can occur in the input. A new online algorithms is presented which does not require such knowledge but matches the previous algorithm in terms of worst case asymptotic competitive ratio. Further results consider how much faster the machine of the online algorithm has to run in order to be able to guarantee that the profit of the online algorithm is the same as the profit of an optimal online algorithm which uses the original slower machine.

The writing is crystal clear and the problems are well presented. The work is also put into context of the existing literature and the new contributions are clearly highlighted and separated from previously known results. Only when certain small folklore results are summarized in the context of bigger proofs, there was some occasional ambiguity over whether a contribution was new or not (for example Lemma 2.5). An additional nice feature of the thesis is that, throughout, many very interesting open problems are identified. It is a beautiful collection of problems that would be an excellent starting point for other researchers who want to begin working in this area.

Overall, this is an excellent thesis that clearly demonstrate the ability to create significant, new, original, and rigorous scientific results and present them in a clear and understandable way. I can recommend, without hesitation, that a PhD degree is awarded to Pavel Veselý.

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