Optimizations in Dynamic Environments

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Abstract

In this research we examine optimization problems in dynamic environments. We consider three different problems with practical applications, from three different domains: personal advertisement, battery management, and transportation networks. These domains are expected to have a large impact on people's lives and on world economics. Hence, we decided to focus on their critical problems. All three problems share the same basic properties as they are NP-hard and can be considered as recourse allocation problems.

The primary goal of this thesis was to solve the problems efficiently despite their hardness. Hence, we have taken an integrative approach to solve them. We combine several methodologies and tackle each problem from several directions. The theoretical methodologies we use include approximation and online algorithms, and the experimental methodologies include heuristic algorithms and simulations. Consequently, the outcome of the research includes theoretical as well as experimental results.

A short description of each of the considered problems and our contributions are presented below.

In the personal advertisement domain, we focus on the problem of personal advertisements allocation with the objective of revenue maximization. Personalization is the next-generation in the world of advertisement, and while its massive use is already apparent in the Internet medium, it has not yet been used in the TV medium as there are still challenges to overcome, such as the revenue maximization. Hence, we consider the problem for the TV medium, including its special constraints and the dynamic environment involved.

ABSTRACT

We propose heuristic algorithms for solving the problem which outperforms the state-of-the-art Integer Programming solver. In addition, we provide a theoretical analysis of the problem, and provide polynomial time approximation schemes (PTASs) to solve restricted instances. Since the problem is a generalization of the well-known Multiple Knapsack Problem, our results are generic and can be applied to other domains as well.

In the battery management domain, we address the problem of extending the battery's life in Electric Vehicles (EVs). The use of electronic vehicles has many advantages. Nonetheless, the EV's current weakness is the battery, which raises several issues such as limited driving ranges and high costs. We decided to focus on one of the issues related to the costs, namely the battery's life. Our approach to extending the battery's life included developing optimization tools for battery management while combining computer science methods with chemistry knowledge.

We propose advanced switching algorithms for managing the battery discharge process in EVs. In addition, we provide several theoretical results regarding the problem hardness and the proposed solutions. To the best of our knowledge, this work is the first to analyze the problem theoretically.

Finally, in the transportation domain, we focus on the flow expansion problem with budget restrictions. Almost any kind of real network is dynamically expanded from time to time. Therefore decision makers face such problems when they need to choose the best approach to improve the graph's flow. We describe a methodology and algorithm that can be used as an efficient tool for decision makers to attain the best improvements in transportation networks when a limited budget is available. The results can be applied to other domains where flow expansion is needed, e.g. expansion of communication networks.