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Green Design of Wireless Local Area Networks by Multiband Robust Optimization

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Abstract

We consider the problem of designing a wireless local area network according to a green paradigm, i.e. serving users with a telecommunication service while minimizing power consumption. To protect against fluctuations in data rate transmission that naturally affect the problem, because of unpredictable user mobility and wireless propagation conditions, we propose a new Multiband Robust Optimization model, and assess its performance on realistic network instances. The preliminary computational experience confirms the effectiveness of the new model in terms of power savings and resiliency against large variations of mobile user positions.

Keywords: Wireless Network Design, User Mobility Uncertainty, Binary Linear Programming, Robust Optimization

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1 Introduction

We consider an optimization problem arising in the design of Green (or energy-saving) Wireless Local Area Networks (GWLAN). A WLAN is composed of a set of Access Points (APs) that provide wireless connectivity to a set of User Terminals (UTs). The problem of optimally designing a GWLAN, introduced in the studied form in [6,7], consists of minimizing the power consumption of a WLAN when the load is scarce, by powering-on just a subset of APs and associating UTs to powered-on APs, while taking into account the data rates between UTs and APs. Efficient heuristics for its fast solution were recently proposed in [4]. To protect the GWLAN against natural fluctuations in the network performance that occur over short periods of time and lead to tricky reductions in data rates, we propose to adopt a Robust Optimization (RO) approach, based on a generalization of the classical Γ-Robustness (Γ-Rob) by Bertsimas and Sim (see [2]). The adoption of RO in GWLAN design aimed at tackling data rate fluctuation has been first investigated in the preliminary study [7], by considering the impact of both user movement and wireless propagation conditions on data rates. In fact, users can move around the service area, and this has a direct impact on the link data rates, which are a function of the distance between users and access points. Furthermore, the data rates of the links are sensible to the fluctuation in the signal propagation.

Here we propose an enhanced RO model for GWLAN design, which is based on Multiband Robust Optimization (MRO). MRO was originally proposed by Büsing and D'Andreagiovanni in [3] to refine Γ-Rob, while maintaining its computational tractability and accessibility. It is essentially based on the use of histogram-like uncertainty sets, which result particularly suitable to represent empirical distributions commonly available in real-world problems (e.g., [1,8]). Specifically, with respect to [7], we propose to use MRO to model the user mobility uncertainty, while we adopt Γ-Rob to model the channel fluctuation event. The rationale is that a more accurate model of the user mobility, via multiple deviation bands, can better represent the real link data rate variations, which are distance dependant, so allowing a finer allocation of

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