Multiband Robust Optimization for the Green Design of Wireless Local Area Networks

Fabio D'Andreagiovanni[1], Rosario Giuseppe Garroppo[2], Maria Grazia Scutellà[3]

[1] Heudiasyc UMR 7253, Sorbonne Universités, Université de Technologie de Compiègne, CNRS, CS 60319, 60203 Compiègne, France
d.andreagiovanni@hds.utc.fr

[2] Dipartimento di Ingegneria dell'Informazione, Università di Pisa, Via G. Caruso 16, 56122 Pisa, Italy
rosario.garroppo@iet.unipi.it

[3] Dipartimento di Informatica, Università di Pisa, Largo B. Pontecorvo 3, 56127 Pisa, Italy
scut@di.unipi.it

Mots-clés : *Wireless Network Design, User Mobility Uncertainty, Wireless Propagation Uncertainty, Binary Linear Programming, Multiband Robust Optimization.*

1 Green and (Multiband) Robust WLAN Design

We consider an optimization problem arising in the energy-saving design (so-called Green design) of Wireless Local Area Networks (GWLAN). A WLAN can be essentially described as a set of Access Points (APs) that provide wireless telecommunication services to a set of User Terminals (UTs). The problem of optimally designing a GWLAN, first presented in [6] in the form that we study, consists in minimizing the power consumption of a WLAN by : i) activating only a subset of APs when traffic load is contained, and ii) associating UTs to activated APs, while taking into account the data rates between UTs and APs. To protect the GWLAN against adverse fluctuations in the data rates that naturally occur over short time periods, we propose to rely on a Robust Optimization (RO) approach, based on a generalization of the classical Γ-Robustness model (Γ-Rob) by Bertsimas and Sim [2].

The adoption of RO in GWLAN design to tackle data rate fluctuations has been first investigated in the preliminary study [6], by considering the impact of both user movement and wireless propagation conditions on data rates. User mobility indeed influences the link data rates, which are a function of the distance between users and access points. Furthermore, the data rates of the links are also influenced by variations in the signal propagation conditions.

In this work, 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, 4] to refine Γ-Rob, while maintaining the computational tractability and accessibility of Γ-Rob. 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, 7]). Specifically, with respect to [6], we propose to use MRO to model the user mobility uncertainty, while we adopt Γ-Rob to model the fluctuations in the wireless channel conditions. The rationale is that a more accurate model of the user mobility, based on the adoption of multiple deviation bands, can better represent the real link data rate variations, which depend on the distance. This allows to derive an improved allocation of the users to the access points, and thus higher reductions in energy consumption. We note that, with respect to the canonical MRO model proposed in [3], here we consider the presence of two distinct uncertain events that are mutually dependent, thus extending the theory of MRO.

We tested the performance of our new model based on MRO on a set of realistic WLAN instances. The tests show that our new model can be solved efficiently and grants important

advantages with respect to Γ-Robustness in terms of the robustness quality of the produced solutions, leading to relevant energy savings.

For an exhaustive description of the new MRO model and theoretical results and of the related computational experience, we refer the reader to the paper [5].

Références

[1] T. Bauschert, C. Büsing, F. D'Andreagiovanni, A.M.C.A. Koster, M. Kutschka, U. Steglich. *Network Planning under Demand Uncertainty with Robust Optimization.* IEEE Communications Magazine 52 (2), 178–185, 2014.

[2] D. Bertsimas, M. Sim. *The Price of Robustness.* Operations Research 52 (1), 35–53, 2004.

[3] C. Büsing, F. D'Andreagiovanni. *New Results about Multi-band Uncertainty in Robust Optimization.* Experimental Algorithms, Springer LNCS 7276, 63–76, 2012

[4] C. Büsing, F. D'Andreagiovanni. *Robust Optimization under Multi-band Uncertainty - Part I : Theory.* arXiv :1301.2734, https ://arxiv.org/abs/1301.2734, 2012

[5] F. D'Andreagiovanni, R.G. Garroppo, M.G. Scutellà. *Green Design of Wireless Local Area Networks by Multiband Robust Optimization.* Submitted for publication to INOC 2017, 2016

[6] R.G. Garroppo, G. Nencioni, M.G. Scutellà, L. Tavanti. *Robust optimisation of green wireless LANs under rate uncertainty and user mobility.* Electronic Notes in Discrete Mathematics, 52, 221–228, 2016

[7] B. Hu, L. Wu. *Robust SCUC With Multi-Band Nodal Load Uncertainty Set.* IEEE Transactions on Power Systems, 31(3), 2491–2492, 2016

[8] D. Tse and P. Viswanath. *Fundamentals of Wireless Communications.* Cambridge University Press, 2005.