




Online Contention Resolution Schemes for Network Revenue Management and Combinatorial Auctions

Will Ma   

Graduate School of Business and Data Science Institute, Columbia University, New York, NY, USA

Calum MacRury   

Graduate School of Business, Columbia University, New York, NY, USA

Jingwei Zhang   

School of Data Science, The Chinese University of Hong Kong, Shenzhen (CUHK-Shenzhen), China

Abstract

In the Network Revenue Management (NRM) problem, products composed of up to L resources are sold to stochastically arriving customers. We take a randomized rounding approach to NRM, motivated by the modern tool of Online Contention Resolution Schemes (OCRS). The goal is to take a fractional solution to NRM that satisfies the resource constraints in expectation, and implement it in an online policy that satisfies the resource constraints with probability 1, while (approximately) preserving all of the sales that were prescribed by the fractional solution.

In NRM and revenue management problems, customer substitution induces a negative correlation between products being demanded, making it difficult to apply the standard definition of OCRS. We start by deriving a more powerful notion of "random-element" OCRS that achieves a guarantee of $1/(1+L)$ for NRM with customer substitution, matching a common benchmark in the literature. We show this benchmark is unbeatable for all integers L that are the power of a prime number, using a construction based on finite affine planes. We then show how to beat this benchmark under any of three assumptions: 1) no customer substitution (i.e., in the standard OCRS setting); 2) products comprise one item from each of up to L groups; or 3) customers arrive in a uniformly random (instead of fixed adversarial) order. Finally, we show that under both assumptions 1) and 3), it is possible to do better than offline CRS when $L \geq 5$.

Our results have corresponding implications for Online Combinatorial Auctions, in which buyers bid for bundles of up to L items, and buyers being single-minded is akin to having no substitution. Our result under assumption 1) or 2) implies that $1/(1+L)$ can be beaten for Prophet Inequality on the intersection of L partition matroids, a problem of interest. In sum, our paper shows how to apply OCRS to all of these problems and establishes a surprising separation in the achievable guarantees when substitution is involved, under general resource constraints parametrized by L .

2012 ACM Subject Classification Theory of computation → Online algorithms

Keywords and phrases Online resource allocation, contention resolution schemes, network revenue management, combinatorial auctions

Digital Object Identifier 10.4230/LIPIcs.ITCS.2026.100

Category Extended Abstract

Related Version *Full Version*: <https://arxiv.org/abs/2403.05378>

Funding *Calum MacRury*: Research was supported in part by an NSERC PDF grant, application #588023-2024.

Acknowledgements The authors thank Huseyin Topaloglu for insightful early discussions.



© Will Ma, Calum MacRury, and Jingwei Zhang;
licensed under Creative Commons License CC-BY 4.0
17th Innovations in Theoretical Computer Science Conference (ITCS 2026).

Editor: Shubhangi Saraf; Article No. 100; pp. 100:1–100:1



Leibniz International Proceedings in Informatics

Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany