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Coupled queueing and charging game model with power capacity optimization

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With the rise of Electric Vehicles (EVs), the demand for parking spots equipped with plugging devices in the charging stations (CSs) is tremendously increasing. This motivates us to study how to improve the Quality of Charging Service (QoX) at these stations. CSs are characterized by their number of parking spots, the maximum power that can be delivered by the station to an EV at one charging point and the power scheduling between the charging points. The latter is based on a modified Processor Sharing (PS) rule, i.e EVs benefit from the maximum power when the number of charging EVs (charging points in use) is sufficiently low, otherwise the total power is uniformly shared. In our model, EVs arrive at the CS according to a Poisson process with a random quantity of energy needed to fully charge their battery. An EV can occupy a charging point without consuming power: each EV has a random parking time and leaves the parking spot only when its parking time expires. We model the arrival of EVs into two CSs. Each new arriving EV determines strategically which CS to join based on a QoX criterion which is the expected probability to leave the chosen station with full battery level. The number of charging EVs at each instant follows a Markov Process and the latter expected probability can be explicitly determined depending on parameters of the system [1]. The strategic decision problem is studied using a queueing game framework [2] and properties of the equilibrium of the game are obtained as well as bounds on the Price of Anarchy (PoA)[3]. Finally our results are illustrated on a particular use-case in which a Charging Station Operator (CSO) is managing both CSs. With a limited total quantity of power for the two CSs, the CSO decides how to share it between the two CSs in order to maximize the QoX at the equilibrium of the game between EVs. An analytical solution of the optimization problem is given. Some numerical illustrations corresponding to a realistic case are provided in order to deepen understand insights of the stochastic model proposed, as the PoA. The results of this work have been published in [4].

References

[1] A. Aveklouris, M. Vlasiou, and B. Zwart, *Bounds and limit theorems for a layered queueing model in electric vehicle charging*, Queueing Systems, 93:83–137, 2019.

[2] R. Hassin, and M. Haviv, *To queue or not to queue: Equilibrium behavior in queueing systems*, Kluwer, 2003.

[3] T. Roughgarden, *Selfish Routing and the Price of Anarchy*, MIT Press, 2006.

[4] A. Dupont, Y. Hayel, T. Jiménez, O. Beaude, C. Wan, *Coupled queueing and charging game model with energy capacity optimization*, in proc. of ASMTA, 2021.