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Fill Rate Window as a Criterion for Spares Allocation

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Abstract : Limited battery range and long recharging times are the greatest obstacles to the successful adoption of electric cars. One of the suggestions to overcome these problems is that carmakers retain ownership of batteries and provide battery swapping service so that customers exchange their depleted batteries for recharged batteries. Motivated by this example, we consider the problem of optimal spares allocation in an exchangeable-item, multi-location repair system. We generalize the standard service measures of fill rate and average waiting time to reflect the fact that customers penalize the service provider only if they have to wait more than a 'tolerable' time window. These measures are denoted as the window fill rate and the truncated waiting time, respectively. We find that the truncated waiting time is convex and therefore a greedy algorithm solves the spares allocation problem efficiently. We show that the window fill rate is generally S-shaped and describe an efficient algorithm to find a near-optimal solution and detail a priori and a posteriori upper bounds to the distance from optimum. The theory is complemented with a large scale numerical example demonstrating the spare battery allocation in battery swapping stations.

Keywords : convex-concave optimization, exchangeable item, M/G/infinity, multiple location, repair system, spares allocation, window fill rate
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