Real-Time Distributed Control for Electric Vehicle Chargers

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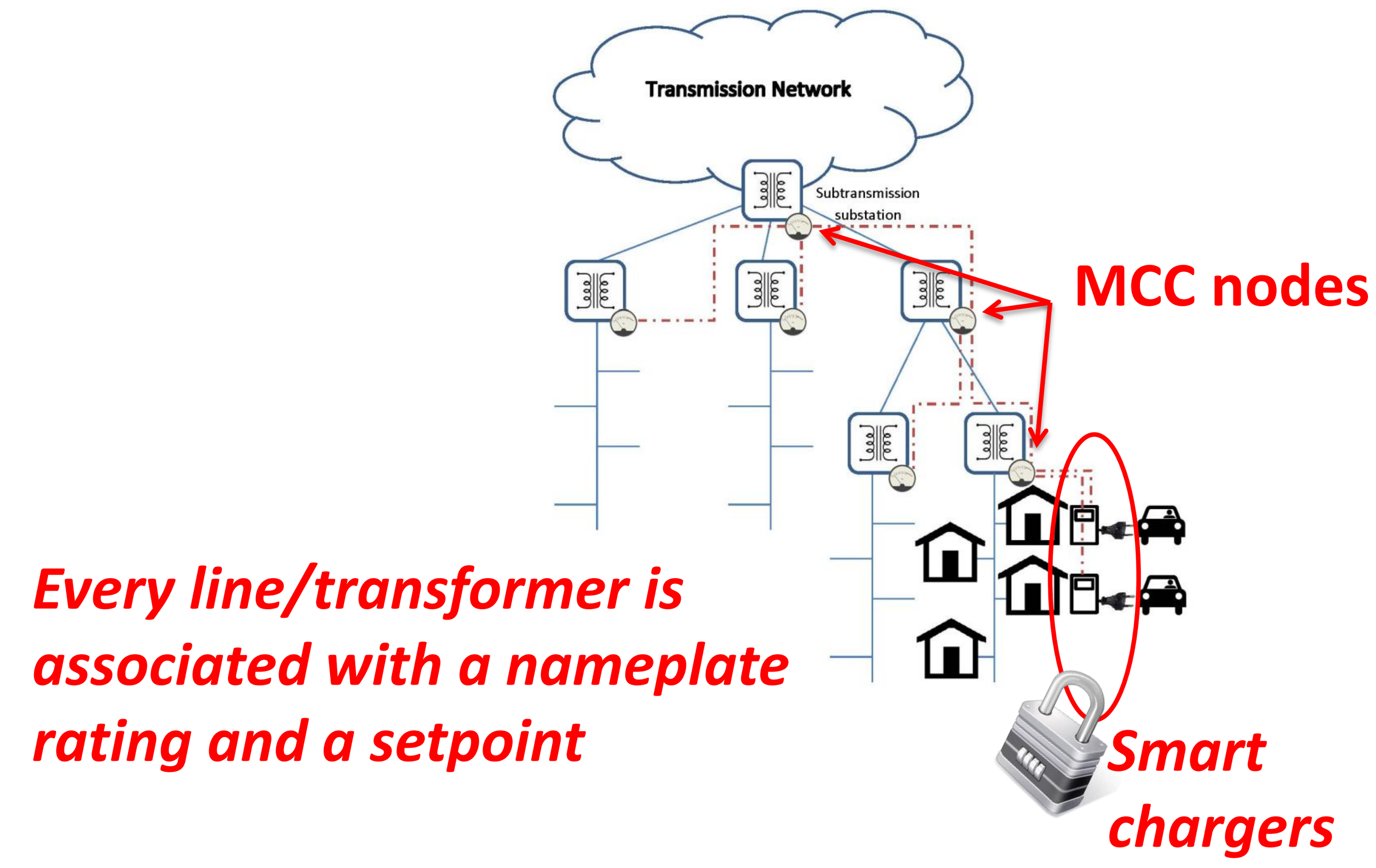
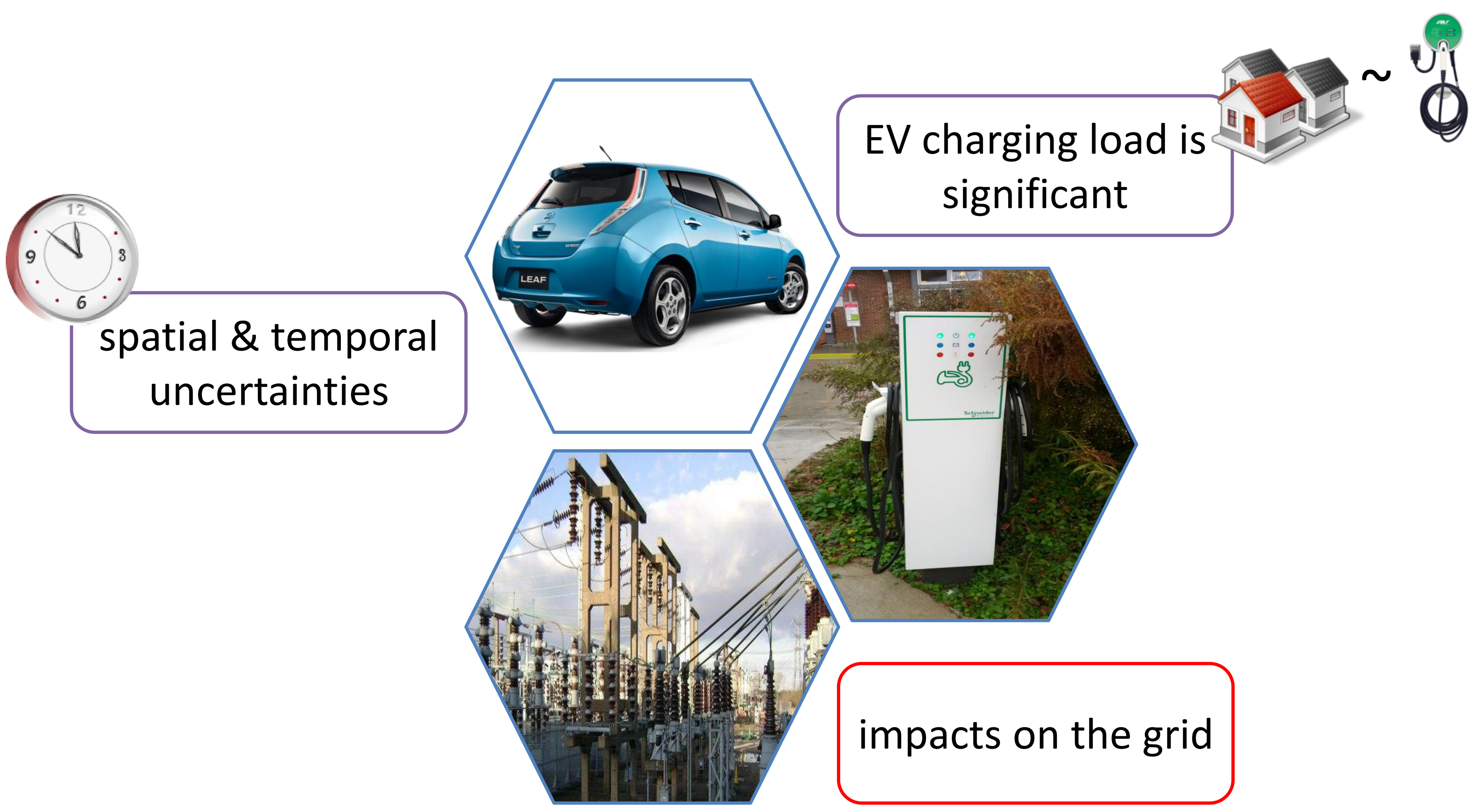
Abstract

At high penetrations, uncontrolled electric vehicle (EV) charging has the potential to cause line and transformer congestion in the distribution network. Instead of upgrading components to higher nameplate ratings, we investigate the use of real-time control to limit EV load to the available capacity in the network. Inspired by rate control algorithms in computer networks such as TCP, we design a measurement-based, real-time, distributed, stable, efficient, and fair charging algorithm using the dual-decomposition approach. We show through extensive numerical simulations on a test distribution network that this algorithm operates successfully in both static and dynamic settings, despite changes in home loads and the number of connected EVs. We find that our algorithm rapidly converges from large disturbances to a stable operating point. Given an acceptable level of overload, we show in a dynamic setting that only 30 EVs could be fully charged without control, whereas up to around 300 EVs can be fully charged with our control algorithm, which compares well with the ideal maximum of 383 EVs.

Control Architecture

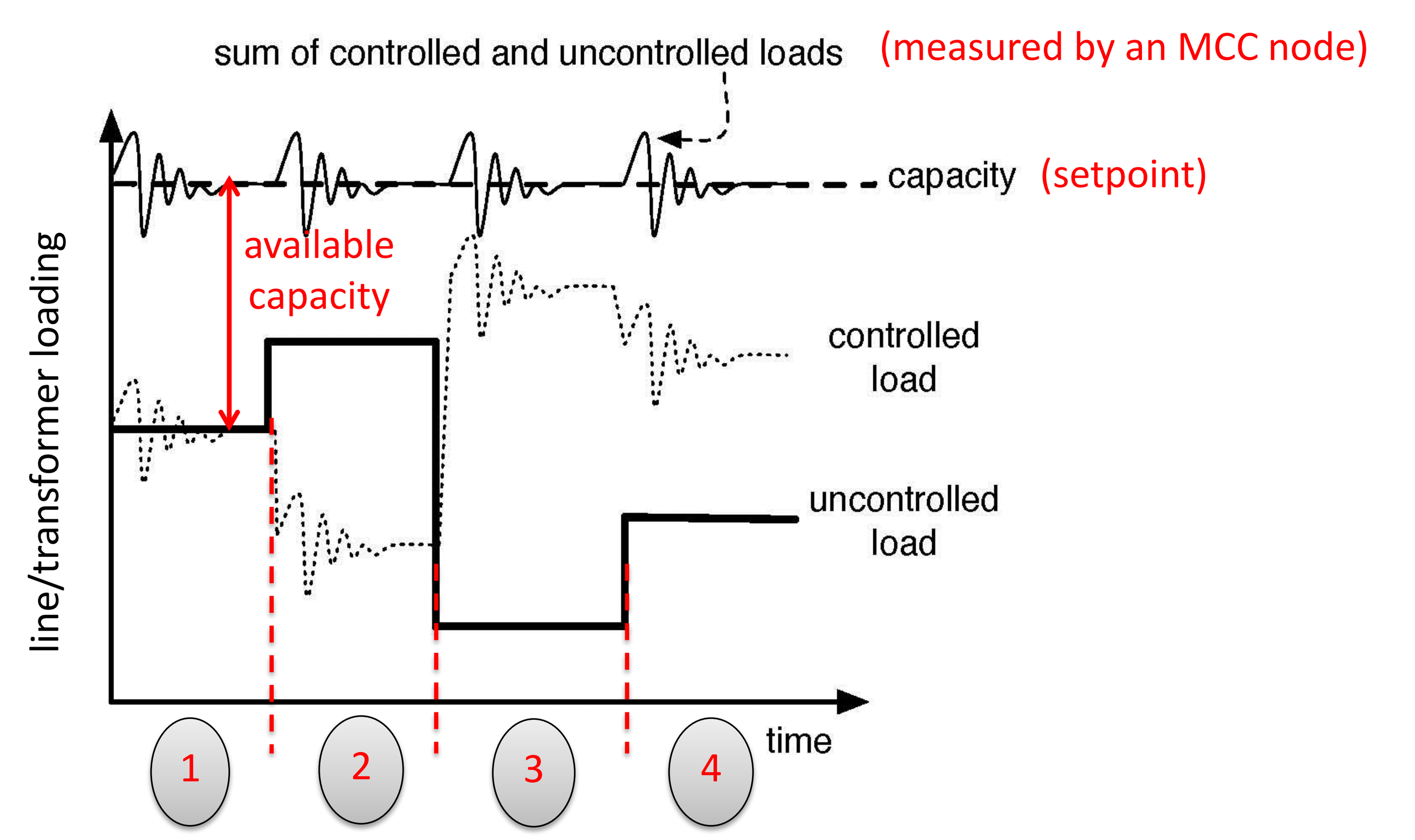


Problem Definition



Certain distribution branches may be subject to significant overloads, while the whole system has sufficient capacity

Single Snapshot Optimization Problem



$$\max_{rate} \sum_{s \in \mathcal{S}} \log(rate_s)$$

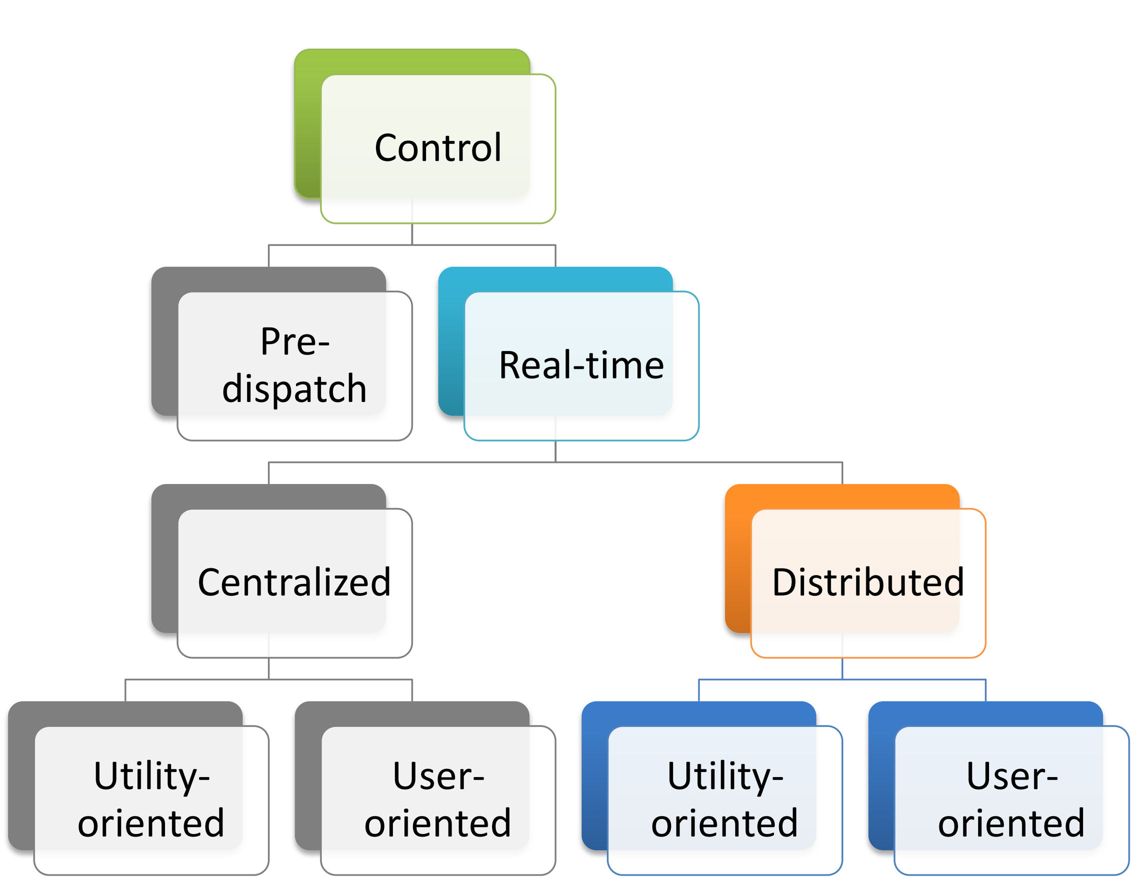
this provides proportional fairness

subject to

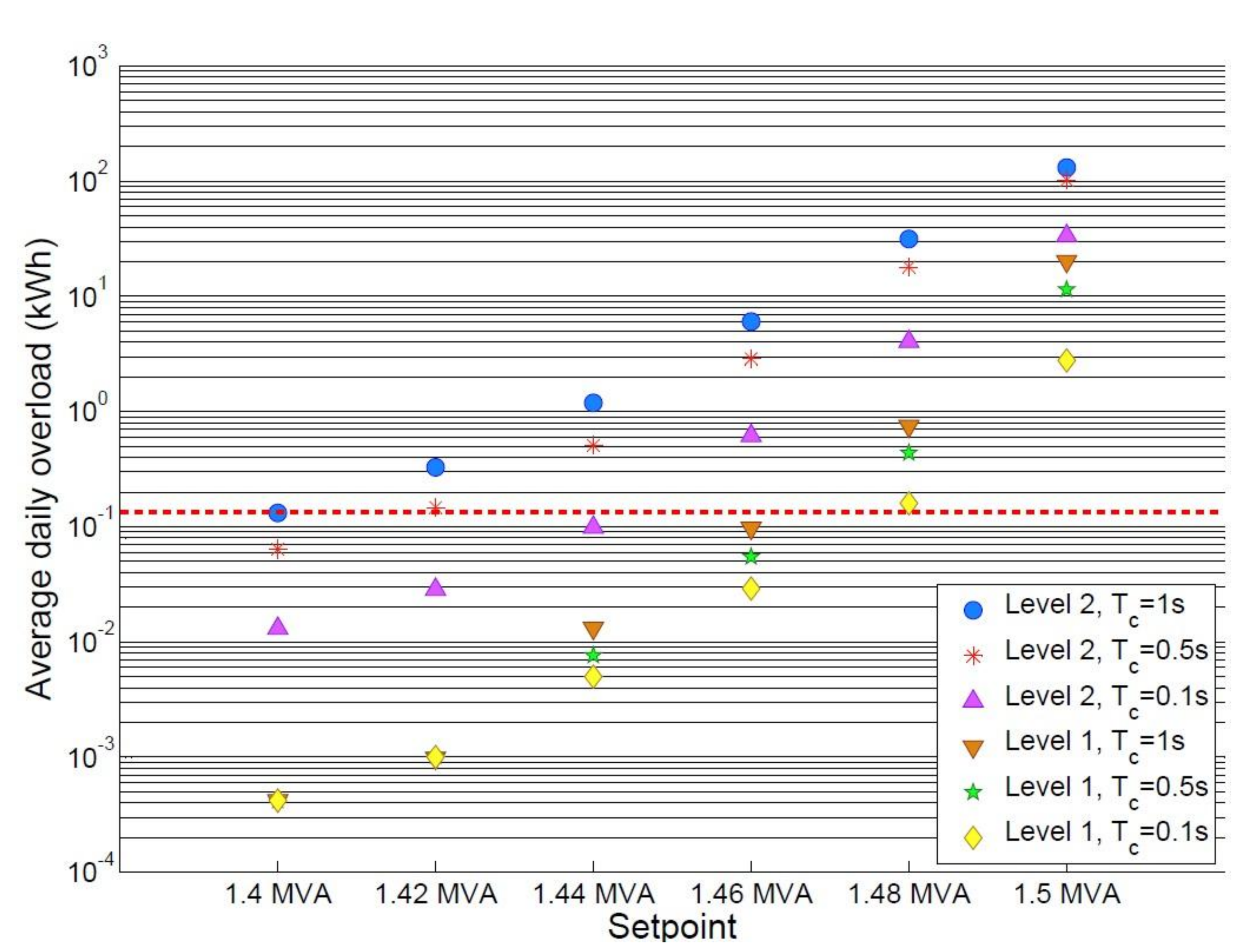
$$0 \le rate_s \le maxrate_s \quad \forall s \in \mathcal{S}$$

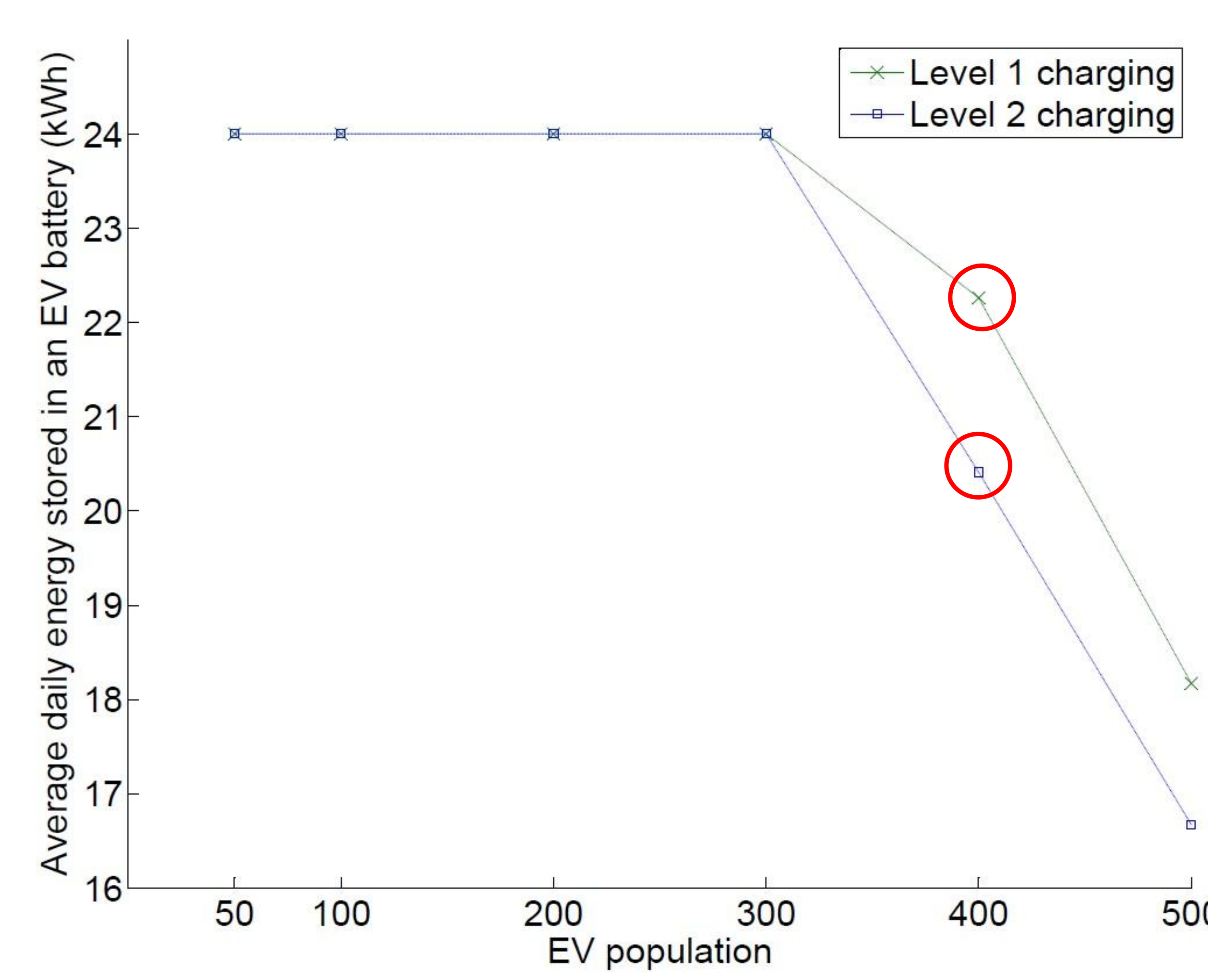
$$EV\ load_l + home\ load_l \le setpoint_l \quad \forall l \in \mathcal{L}$$

Solution Approaches



Results





References

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