Relating Electric Vehicle Scheduling to Processor Speed Scaling and Network Flow Problems

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In application-driven algorithmic research, considered problems often relate or even translate to already existing problems and methodologies. One such example is the electric vehicle (EV) scheduling problem, where each job j is defined by a release time r_j (arrival of the EV), deadline d_j (departure of the EV), processing work p_j (energy to be charged) and job-specific speed limit ℓ_j (maximum power at which the EV may charge). A natural objective function is the flatness of the aggregated speed profile, usually modelled as the integral of the squared speed profile. The problem is particularly relevant for control algorithms at large parking lots, where the synchronized power demand exceeds the available power capacity.

Over the past years, we have followed a research line that relates the EV scheduling problem to two distinct (but connected) problems: (i) processor speed scaling [1] and (ii) majorized network flows [2]. Among others, this research resulted in an exact algorithm [3] (illustrated in Fig. 1) for a whole class of optimization problems, as well as valuable insights into the relation between all three problems.

References

[1] F. Yao, A. Demers, and S. Shenker, "A scheduling model for reduced CPU energy," in *Annual Symposium on Foundations of Computer Science*. IEEE Computer Society, 1995, pp. 374–382.

[2] A. F. Veinott, "Least d-majorized network flows with inventory and statistical applications," *Management Science*, vol. 17, no. 9, pp. 547–567, 1971. [Online]. Available: https://doi.org/10.1287/mnsc.17.9.547

[3] L. Winschermann, M. E. T. Gerards, A. Antoniadis, G. Hoogsteen, and J. Hurink, "Relating electric vehicle charging to speed scaling with job-specific speed limits," 2024.

j	r_j	d_j	p_j	ℓ_j
1	0	3	2	2
2	1	2	2	2

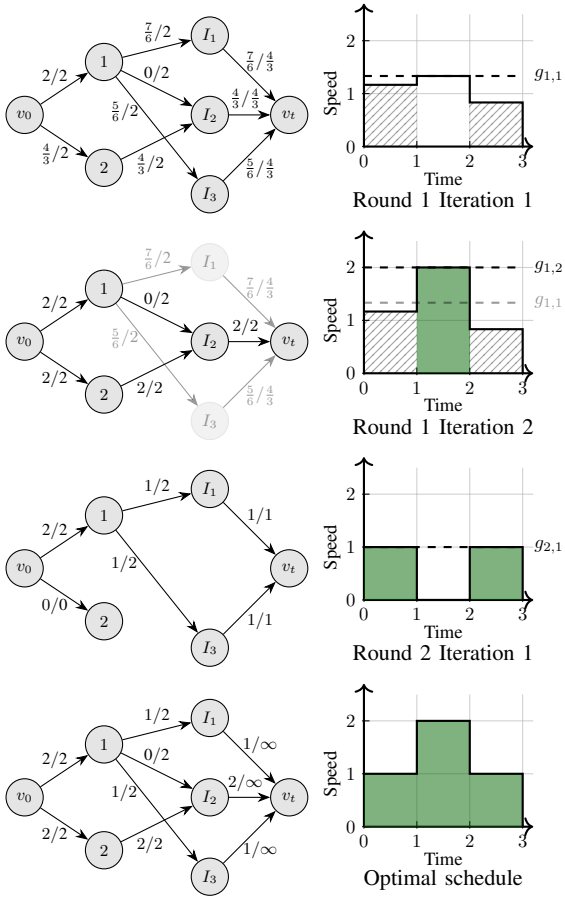

Fig. 1. Intermediate states of exact algorithm FOCS for an example instance, tracked over rounds and iterations.