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A Comprehensive Modelling Framework for Demand Side Flexibility in Smart Grids

Lukas Barth (ITI), Nicole Ludwig (IAI), Esther Mengelkamp (IISM), Philipp Staudt (IISM)

Literature

Reference	Time Frame	Interruptible Jobs	Storage	Interdependent Jobs	Earliest Start Time	Deadline	Production	Multiple Resources	Base loads	Modes	Drain, Losses	Down-/Uptime	Multiple Runs	Ramping
Allerding (2012)	discrete	✓	✗	✗	✓	✓	✗	✗	(✓)	✗	✗	✗	✗	✗
Ashok (2000)	discrete	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗
Ashok (2006)	discrete	✓	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓
Castro (2002)	continuous	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗
Fink (2014)	discrete	✗	✓	✗	✗	✗	✗	✗	✓	✗	✓	✓	✓	✓
Gottwalt (2016)	discrete	✓	✓	✗	✓	✓	✗	✗	✓	✗	✗	✓	✓	✗
Luo (1998)	discrete	✗	✗	✗	✗	✓	✓	✗	✗	✓	✓	✓	✓	✗
Mitra (2012)	discrete	✗	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
Moon (2014)	discrete	(✓)	✓	✓	✗	✓	✓	✓	(✓)	✓	✗	✓	✓	✓
Oudalov (2007)	discrete	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗
Petersen (2013, 2014)	discrete	✗	✓[a]	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓	✗
Schilling (1996)	continuous	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✗	✓	✗
Sou (2011)	continuous	(✓)	✗	✓	(✓)	✓	✗	✗	✓	✓	✗	✓	✓	✗
This paper	discrete	(✓)	(✓)	✓	✓	✓	✓	✓	✓	✓	(✓)	(✓)	(✓)	✓

[a] Only integrated in the first paper by the authors.

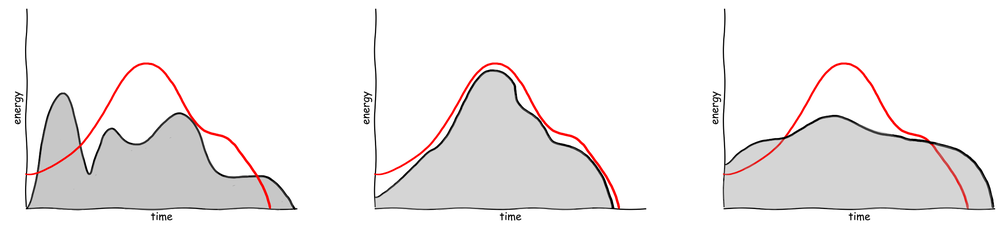
Objective Function

Aim 1: Minimize amount of energy bought from the grid

$$\min \sum_t c(t) \cdot \left(E_{prod}(t) - \hat{P}(t)\right)$$

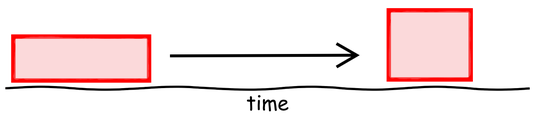
Aim 2: Reduce the peak energy load to save connection costs

$$\min \left(\max_t \hat{P}(t) \right)$$



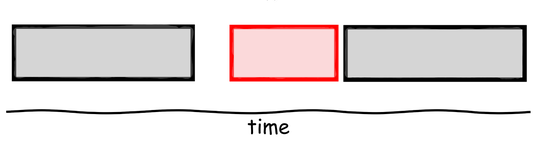
Interdependent Jobs

$$\sigma_i + L_{i,j} \leq \sigma_j$$



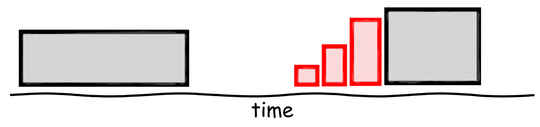
Drain

$$T_i = \tilde{\phi}_i \cdot \tilde{T}_i + \sum_k \tau_{k,i} \left(\sigma_i - \eta_k\right)$$



Ramping

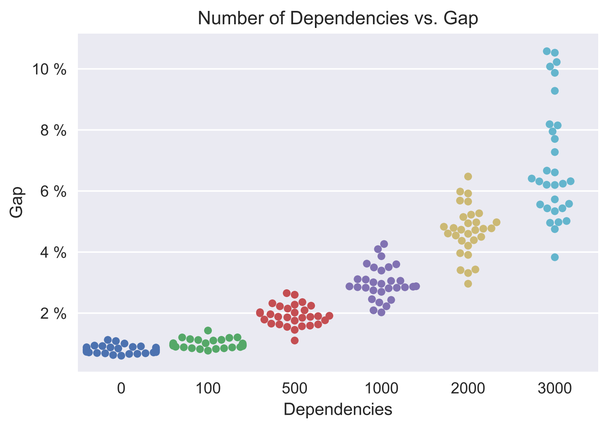
$$\rho_{j,\lambda} \cdot M \geq \left(\sigma_j - \eta_i - \delta_{i,j,\lambda}\right)$$

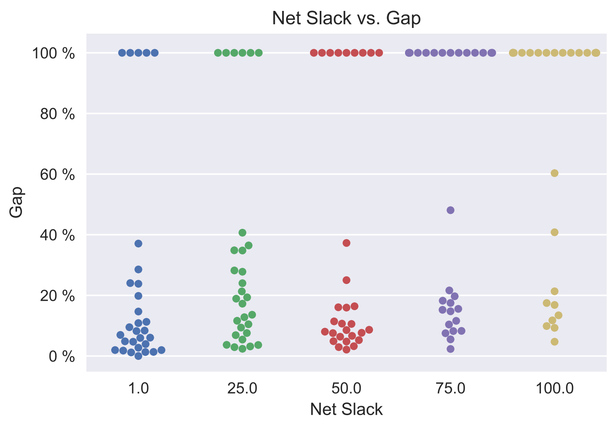


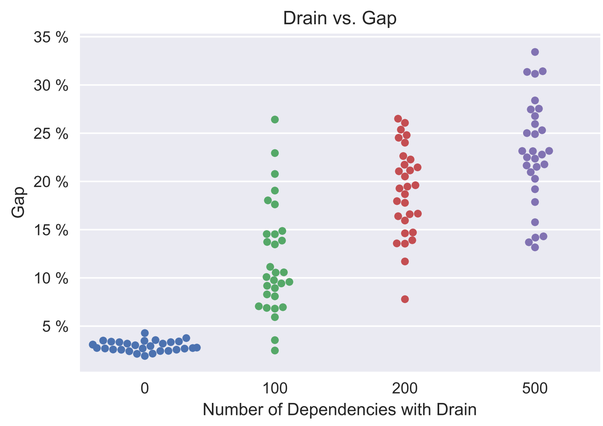
Total Power Requirement

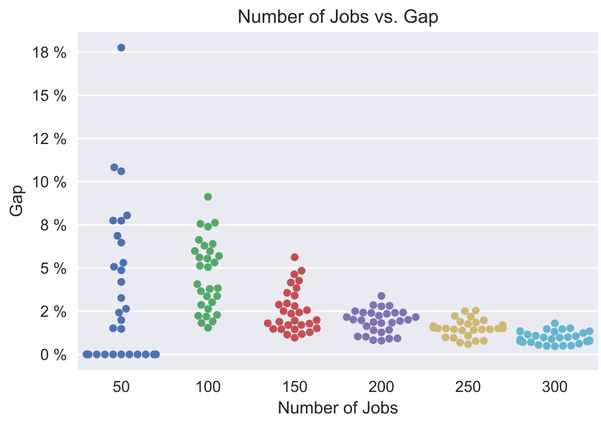
$$\hat{P}(t) = \underbrace{\sum_i \left(P_i \sum_{t - T_i < t' \leq t} s_i(t') \right)}_{\text{power of all running jobs}} + \underbrace{\sum_j R_j(t)}_{\text{power of jobs currently ramping}}$$

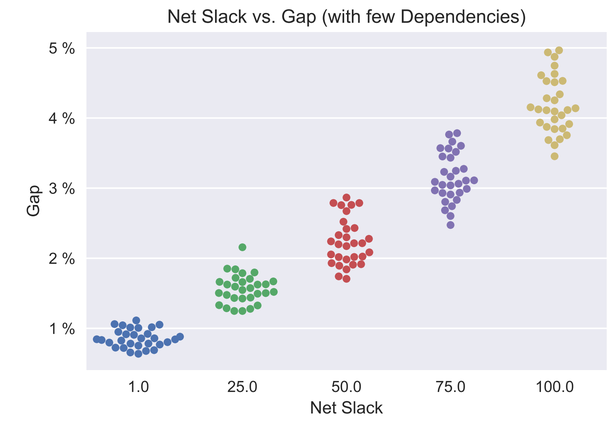
Experimental Evaluation

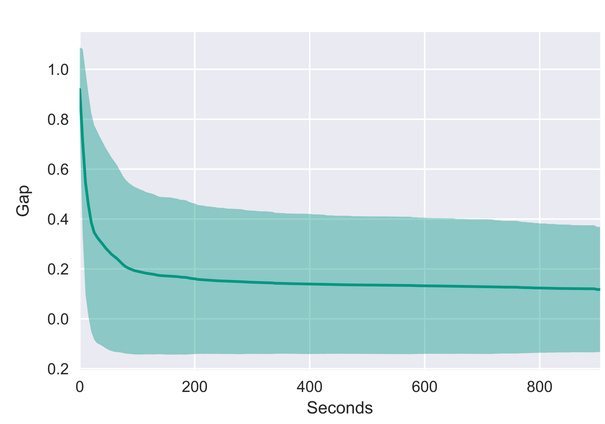












Based on: Barth, Lukas; Ludwig, Nicole; Mengelkamp, Esther; Staudt, Philipp (2017): A comprehensive modelling framework for demand side flexibility in smart grids. In: Comput Sci Res Dev 30 (4), S. 1758.