Optimized Schedule-Based Operation Planning of Flexibilities

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1. Introduction

The importance of flexibility for a successful energy system transformation and the potential for the energy markets are inevitable. For the optimal integration into the existing schedule-based energy system the provision of flexibility should be schedule-based as well. To map the entire range of a flexible asset a flexibility provider can offer several alternative schedules to a grid operator or a marketer (e.g. an aggregator). Based on congestion- or price-forecasts, the flexibility user has to select a cost-efficient combination of the offered flexibilities to meet his demand.

In order to find the optimal solution, for these combinatorial optimisation problems, schedules from different flexibility providers have to be evaluated in relation to each other. This leads to a multiplying number of possibilities depending on the number of alternative schedules provided, which may result in huge calculation times for mathematic optimization models.

This publication describes a heuristic approach to solve this non-separable optimization problem in a moderate amount of time.

2. Method

Using the *Combinatorial Optimisation Heuristic for Distributed Agents* (COHDA) approach, each flexible asset's schedules are modelled by an agent [1]. These agents are connected to an association in a swarm forming overlay topology (shown in **Figure 1**) in order to reduce the communication effort during the optimization.

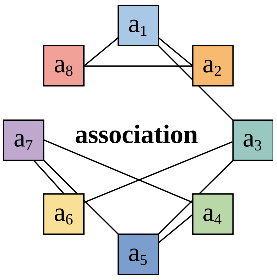

Figure 1: *Example overlay-topology for eight agents a_n*

The primary optimisation target of an association is to cover the demand of the flexibility user measured by the *delivery quality*. If the demand can be covered completely, the association tries to find the most cost-efficient solution (increase *cost quality*).

In each optimization step, an agent receives a possible solution candidate from a connected neighbour. If the received solution qualities or the flexibility demand do not differ from the agent's internal memory, the algorithm proceeds with the next agent (1st convergence criteria). Otherwise the agent can interact in three different ways with the solution candidate:

1. Add a schedule
2. Exchange a schedule
3. Delete a schedule

If the overall quality of the new solution is higher, the agent stores the adapted solution candidate in his memory (2nd convergence criteria) and transmits this solution to its connected neighbours.

The optimization algorithm terminates, when all agent memories contain the same solution candidate or the maximum iteration steps are reached.

3. Results

The optimization result for a fictional demand of a grid operator is shown in **Figure 2**. 100 flexibility providers with up to ten alternative schedules and different power levels were utilized. Caused by its heuristic nature the algorithm only finds a local optimum.

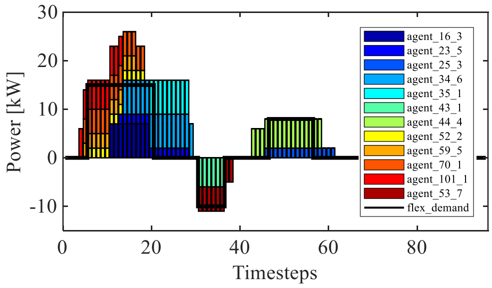

Figure 2*: Optimized schedule selection in 2.09 s*

Besides the displayed results, the algorithm is capable to calculate the optima for different *delivery qualities*. Therefore, it can be adopted easily to other applications, such as the flexibility aggregation for the control reserve market.

4. Literature

[1] Hinrichs, C.: Selbstorganisierte Einsatzplanung dezentraler Akteure im Smart Grid, Universität Oldenburg, 2014.