Aggregators Efficiency in Distributed Power Networks

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Outline

1. Distributed Power Networks
2. DIPONET (Combined Learning and Optimization)
3. Aggregator efficiency and simulations
Power Networks with Prosumers

A grid of micro-grids
A Completely Distributed Power Management System for Renewable Energy

Funders:
- E.ON Energy
- DFG: German Research Foundation
DIPONET (our contribution)

Distributed learning

- **Reinforcement learning**: estimate and anticipate the bidding price
- **Feedback**: the optimization takes into account the price

Optimization

- **Energy storage**
- **Interaction**
Reinforcement learning

preference:
\[ p(t+1, s) := p(t, s) + \alpha (r(t, s) - p(t, s)); \ 0 < \alpha \leq 1 \]

Optimization problem (Dynamic programming)

Decision variables : \(-k \leq x_i \leq +k, \ x_i : Z\)

\[ x_i \] is the variation for slot \( s_i, \ i = 1, \ldots, n \)

Cost function

to be minimized : \[ f(x_1, \ldots, x_n) = \sum_{i=1}^{n} (o(x_i) + q_i)p(i, s) \]

Optimal cost : \[ C = \min_{x_1,\ldots,x_n} \sum_{i=1}^{n} (o(x_i) + q_i)p(i, s) \]
Algorithm description

Subproblems: $C_j(y_j) = \min_{x_1, \ldots, x_j} \sum_{i=1}^{j} (o(x_i) + q_i)p(i, s) \quad j = 1, \ldots, n$

: $\forall i'. \ 1 \leq i' \leq j, \quad 0 \leq r_0 + \sum_{i=1}^{i'} x_i \leq r$

: $r_0 + \sum_{i=1}^{j} x_i = y_j \quad 0 \leq y_j \leq r$

Dynamic programming: $C_j(y_j) = \min_{-k \leq x_j \leq k} C_{j-1}(y_j - x_j) + (o(x_j) + q_j)p(j, s)$

: $C_0(y_0) = \begin{cases} 0 & \text{if } y_0 = r_0 \\ \infty & \text{else} \end{cases}$

: $C_n(r_0) = C$
Aggregator Optimization model

Decentralized aggregator
- Each prosumer independently exploits the control model proposed.

Centralized aggregator
- A group of prosumer is globally controlled by an aggregator.

Aggregator efficiency
- Based on the type of the network
- The flexibility of prosumers
Distributed Power Networks
DIPONET (Combined Learning and Optimization)
Aggregator efficiency and simulations

DIPONET vs DEZENT

![Graph comparing energy cost for DEZENT and DIPONET consumers over 24 hours.](image)

DEZENT consumer
DIPONET consumer

A. Tcheukam
Optimization model of one prosumer

![Graph showing unit cost energy and optimal profile over 24 hours for two days.](image)

- **Unit cost energy (cent):**
  - Day 2: Black line
  - Day 3: Dotted blue line

- **Energy profiling (x150KW):**
  - Day 2: Red dashed line
  - Day 3: Blue line
Energy cost achieved by the consumer population

![Graph showing energy cost over time for centralized aggregator, decentralized aggregator, and without aggregator.]
Energy cost at the end of the day achieved by the consumer population

![Graph showing energy cost over hours for centralized aggregator, decentralized aggregator, and without aggregator.](image-url)
Aggregators: profit realized.
Conclusion

Model
- combination of reinforcement learning and optimisation.
- simulation results show that our approach is more efficient than the approach used in DEZENT.

Aggregator’s impact
- make use of the flexibilities of the prosumers.
- provide active demand service in the market.

Future works and Applications
- Introduction of Mean-Field-Games in distributed power networks.
Bibliography


A. Tcheukam and H. Tembine, "Mean-Field-Type Games for Distributed Power Networks in Presence of Prosumers", the 28th Chinese Control and Decision Conference (CCDC), May 2016.