Aggregators Efficiency in Distributed Power Networks

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ENERGY 2016

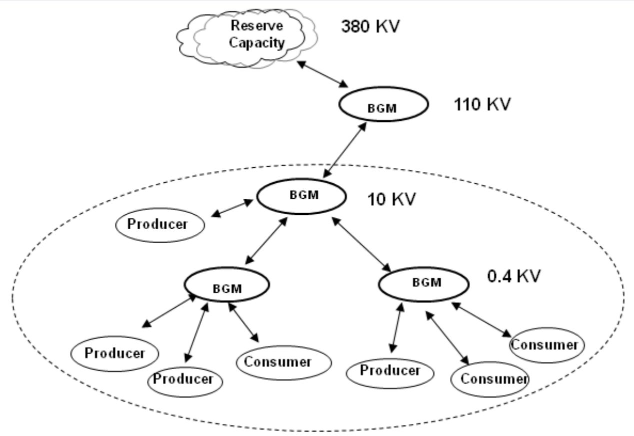
NEW YORK UNIVERSITY

L&G lab

Outline

Power Networks with Prosumers

A grid of micro-grids



R&D Project: DEZENT

- A Completely Distributed Power Management System for Renewable Energy
- Funders:
  - E.ON Energy
  - DFG: German Research Foundation

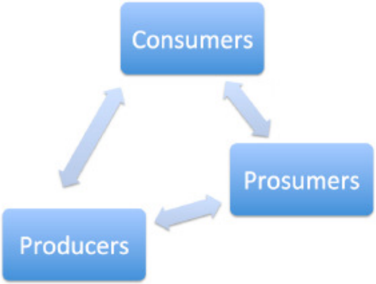
DIPONET (our contribution)

Distributed learning

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

Optimization

- Energy storage
- Interaction



DIPONET (Combined Learning and Optimization)

Reinforcement learning

preference:

$$p(t+1,s) := p(t,s) + \alpha\left(r(t,s) - p(t,s)\right);\ 0 < \alpha \leq 1$$

Optimization problem (Dynamic programming)

Decision variables : $-k \leq x_i \leq +k,\ x_i : \mathbf{Z}$

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

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

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

Dynamic programming : $C_j(y_j) = \min_{\substack{-k \leq x_j \leq k \\ 0 \leq y_j - x_j \leq r}} C_{j-1}(y_j - x_j) + (o(x_j) + q_j) p\,(j,s)$

: $C_0(y_0) = \text{ if } y_0 = r_0 \text{ then } 0 \text{ else } \infty$

: $C_n(r_0) = C$

Aggregator Optimization model

Decentralized aggregator

- Each prosumer independently exploits the control model proposed.

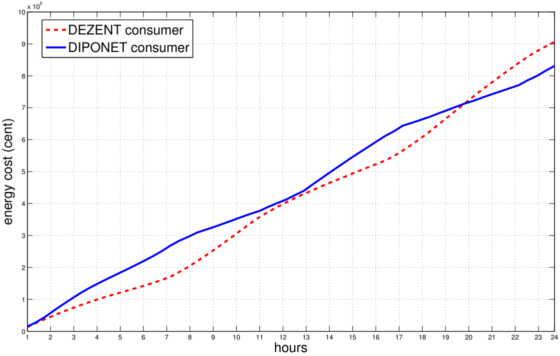
Centralized aggregator

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

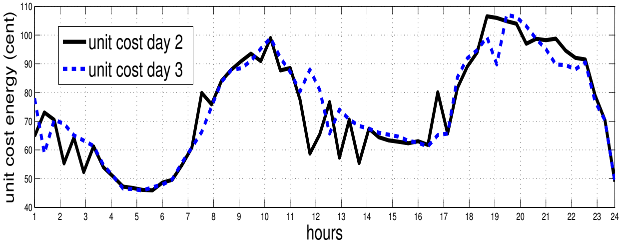
Aggregator efficiency

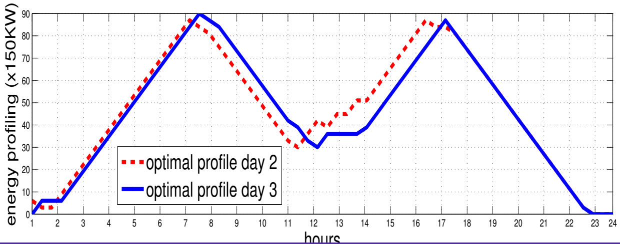
- Based on the type of the network
- The flexibility of prosumers

DIPONET vs DEZENT

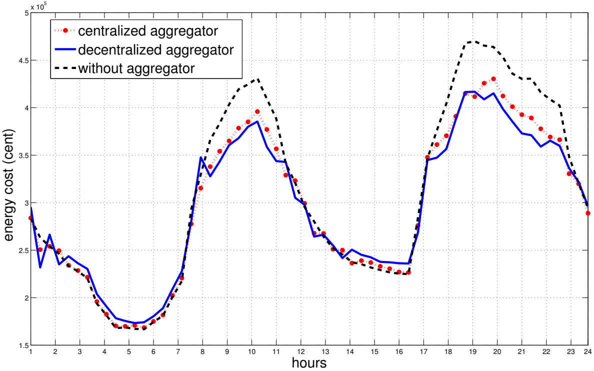


Optimization model of one prosumer

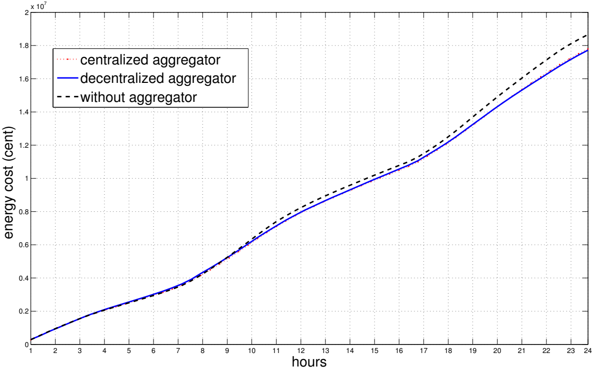




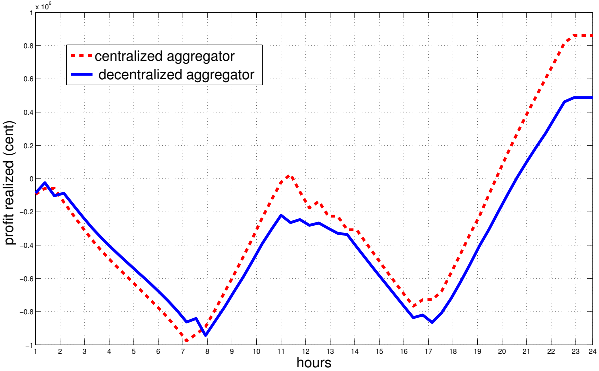
Energy cost achieved by the consumer population



Energy cost at the end of the day achieved by the consumer population



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.

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