

Scalable Coalition Formation For Electricity Consumers

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Aims

Coalition formation often offers very limited practical use due to the complexity of the computations involved.

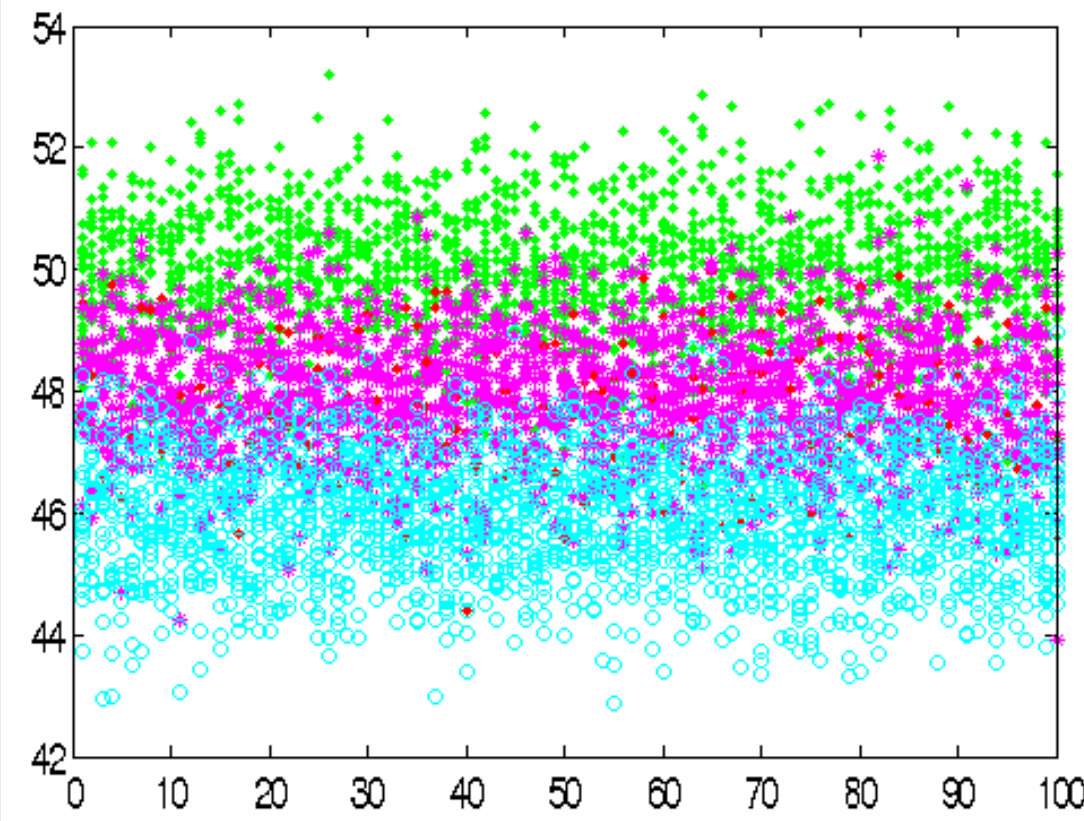
In order to be able to apply coalition formation to real world problems, we aim to provide an algorithm for the problem of dividing the value of a coalition consisting of thousands of agents.

In doing so, we take into account the fairness of the divisions, and consider variable deadlines for the computations.

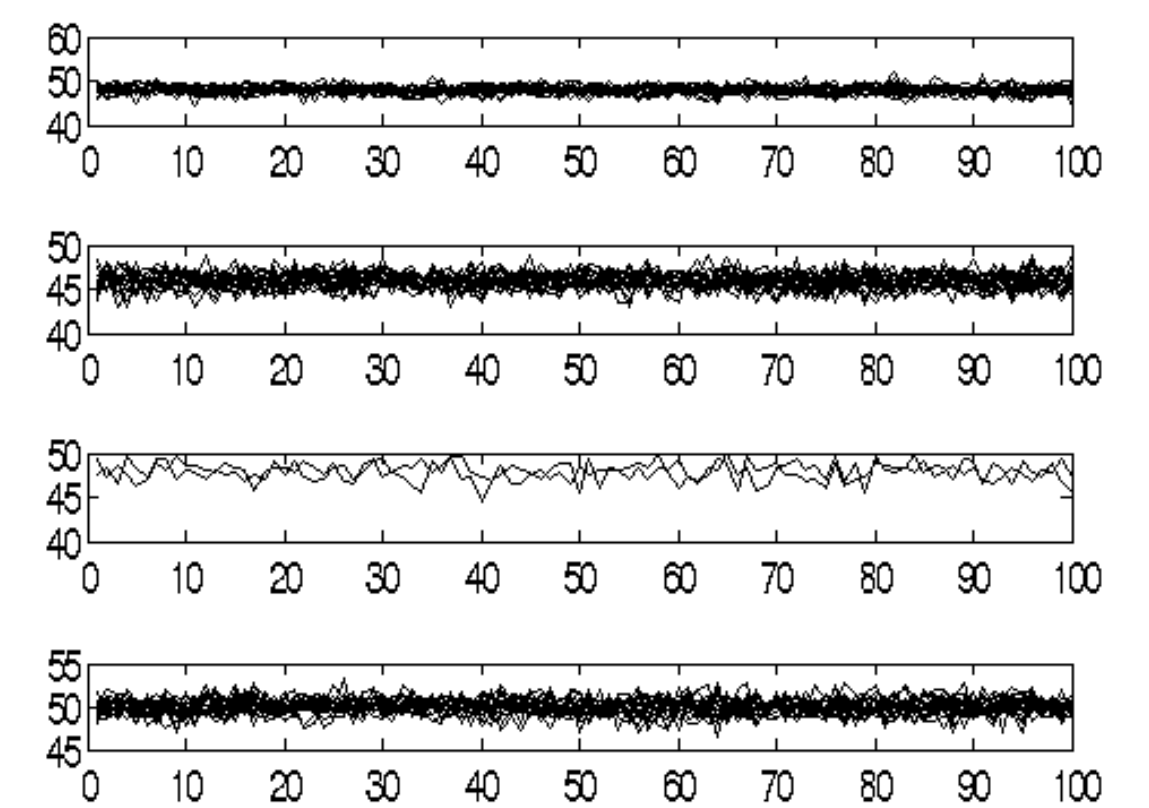


Clustering Consumptions

We use Gaussian Mixture Models to cluster the agents' consumptions



Agents can be cluster based on the similarity of their consumption in daytime, night-time, or both.



Shapley-Value Profit Sharing

The Shapley value, which is the the average marginal contribution of an agent to the rest of agents, is a "fair" way to distribute the profit of a coalition, in the sense that it enforces certain desirable properties.

- 1) **Efficiency:** The total profit is distributed.
- 2) **Symmetry:** Equal agents receive equal profits.
- 3) **Additivity:** The Shapley value is an additive function (of characteristic functions).
- 4) **Zero Player:** An agent with zero contribution receives zero profit.

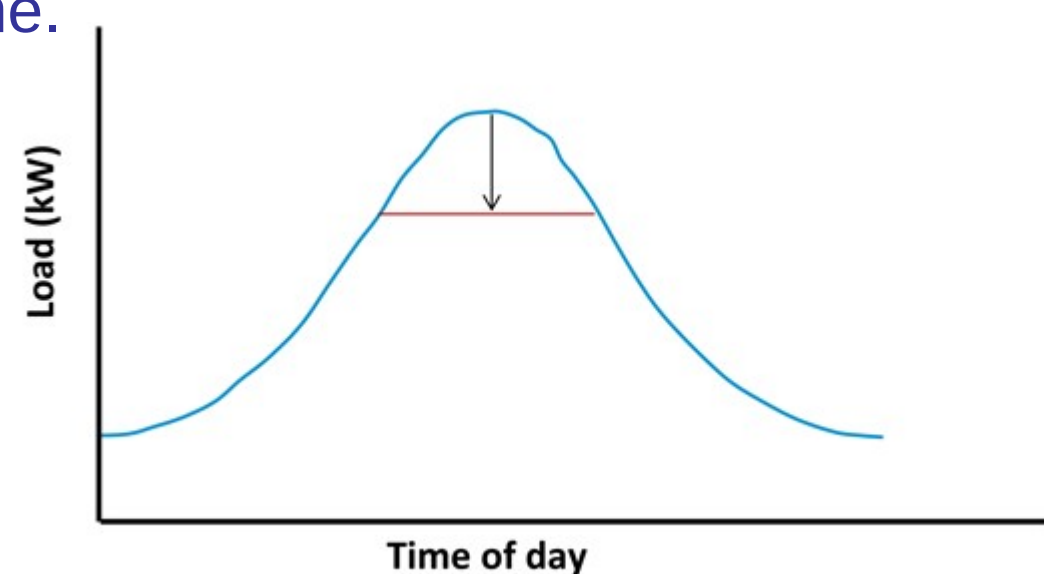
$$\phi_i(v) = \sum_{S \subseteq N \setminus \{i\}} \frac{|S|! (n - |S| - 1)!}{n!} (v(S \cup \{i\}) - v(S))$$

Any-time Computation of the Shapley Value

- 1) Cluster the agents and treat similar agents as identical.
- 2) Compute the Shapley value as follows:
 - 1) Identical agents are given equal Shapley values, thus are computed only once.
 - 2) Until the deadline, each agent's average marginal contribution to as many sub-coalitions of the grand coalition as possible are incrementally computed.
 - 3) The values that are left out are found by interpolating the computed ones.

Coalitions of Electricity Consumers

- Electricity can be bought at a cheaper price if the demand is flat over the course of a day.
- We form coalitions of electricity consumers and aggregate their consumptions.
- Aggregating anti-correlated consumers results in reducing the total peak.
- This is a superadditive game.



Incremental Computation of the Shapley Value

