

Coalition Formation Algorithm of Prosumers in a Smart Grid Environment

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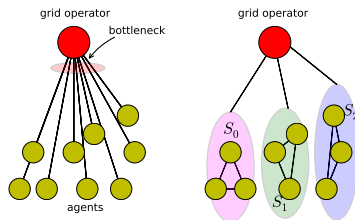
16 december 2014,

disponible sur ArXiv à : <http://arxiv.org/abs/1410.8776>

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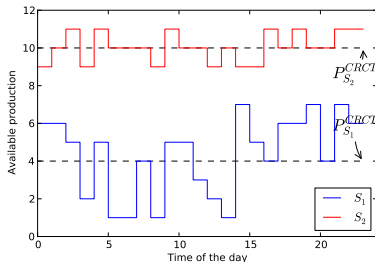
Objective

- Data/Communication oriented
- **Prosumer** scenario (agents consume, produce, and sell to the grid)
- **Minimizing** the amount of **communication** needed to maintain stability
- Avoid communication **bottlenecks**
- Organizing prosumers into virtual (logical rather than physical) **coalitions** (geographical distances are abstracted)
- Reduce the "*grid to agents*" communication flows
- How should these coalitions be formed ?



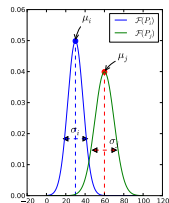
Challenges

- Suppose coalitions are formed **on day d for day $d + 1$**
- A **contract value** is decided for each coalition
- Over day $d + 1$, coalition net productions are likely to oscillate because :
 - ▶ agents **consume freely**
 - ▶ production is based on **renewables** (lots of **uncertainties**)
- BUT, for the grid operator, coalition **productions should remain stable** at their contract values
- Coalitions need **communication** to take actions (battery charge/discharge, load shedding, backup generators)



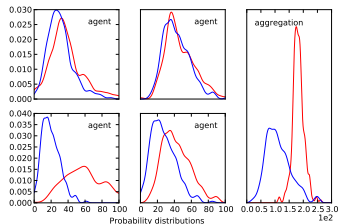
We want to minimize the amount of communication needed by forming coalition that, statistically speaking, will be likely to deviate less on day $d + 1$

- Agents net production timeseries exhibit **diverse patterns** because of (mainly) :
 - Weather conditions at the agent location
 - The DER owned by the agents
 - The agents consumption habits
- Probability distributions** inferred from past values
- $\sigma_{ij} = \sqrt{\sigma_i^2 + \sigma_j^2 + \rho_{ij}\sigma_i\sigma_j}$
- We use the **Pearson correlation coefficient** to simplify the model
- We want to **cluster together uncorrelated agents**
- Unusual** and **complex** objective



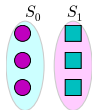
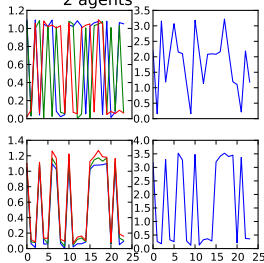
$$\mathcal{F}(P_j) = \mathcal{N}(\mu_j, \sigma_j)$$

$$\mathcal{F}(P_i) = \mathcal{N}(\mu_i, \sigma_i)$$

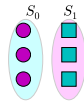
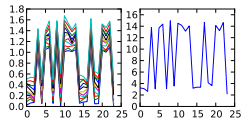
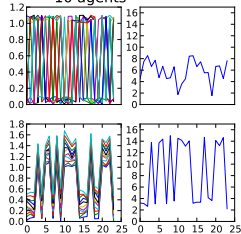


Uncorrelated / Diversity Idea

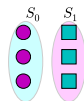
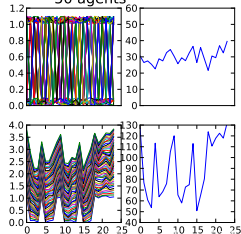
2 agents



10 agents



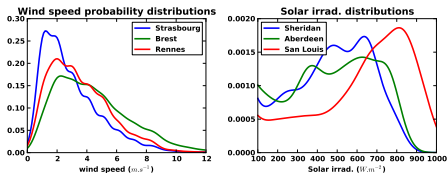
50 agents



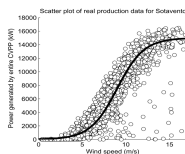
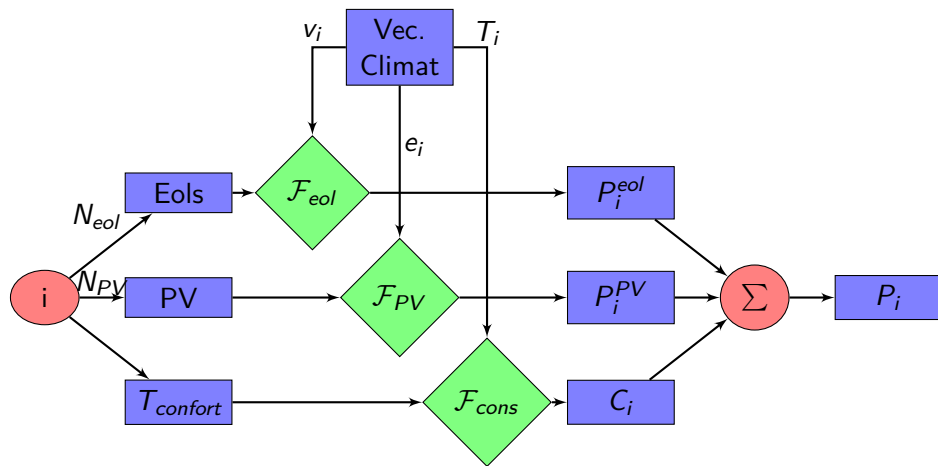
In the model, each agent is represented by the **timeserie** of its **net instantaneous production** (production - consumption)

Data

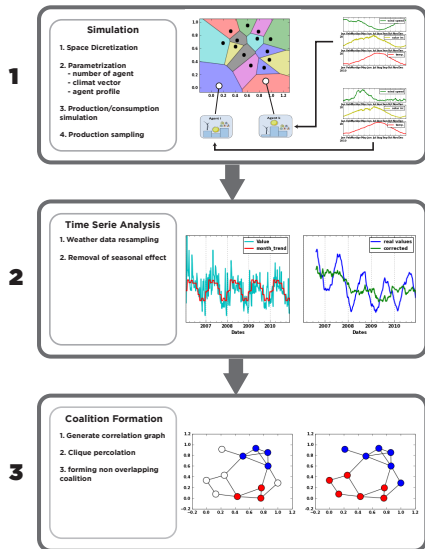
- Consumption and production data with **fine granularity**
 - Geo-localized data
 - "High" sampling frequency (second to hour range)
-
- "Real prosumers" do not really exist yet (necessity to model them)
 - We use **weather data** available for stations accross a given territory
 - These traces are used to generate net production traces for prosumer agents (see more details on next slide)



Aggregated net prosumer production model

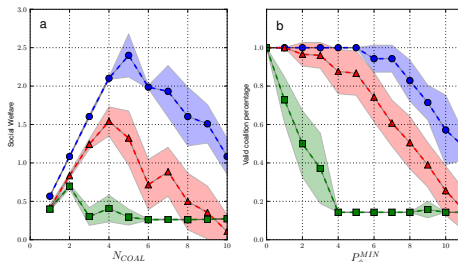
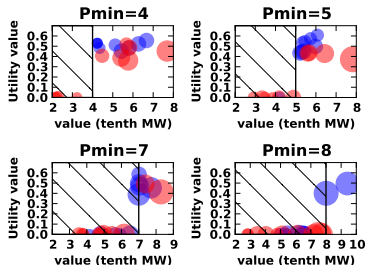


Our Method (Overall view)



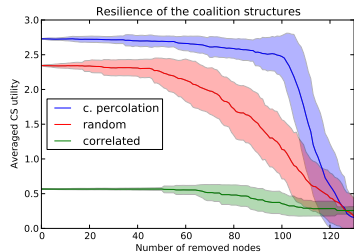
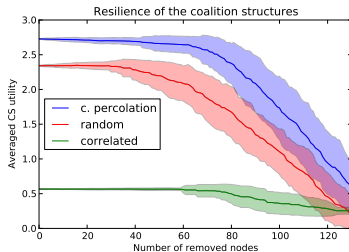
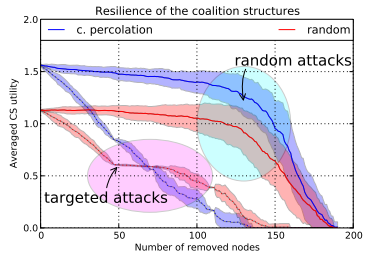
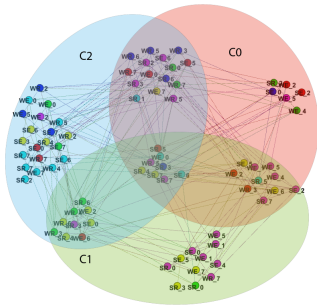
- Some examples considered :
- France (Lille, Brest, Dijon, Strasbourg, Bordeaux, Marseille...)
- USA (Colorado, Kansas, Montana, Texas, Oklahoma...)
- 200 agents
- 16 zones (16 climate vectors)
- Timeseries from 01/01/2006 to 31/12/2010

Some Results (part 1)



- Coalitions are able to sell (positive utility) if
 - ▶ They produce more than P_{min}
 - ▶ With a low probability of producing less than the contract

Some Results (part 2)



Conclusion and Perspectives

- Communication oriented
- Modeling, simulations
- Use of statistical tools, complex systems, graph theory
- Lack of available "clean" data led us to construct our own "*traces generator*"
- Strong assumptions on the electrical part
- Studying the impact of electric constraints on the model could lead to an interesting and more realistic work