Analysis and control of system dynamics driven by objective oriented agents. Application to power systems.

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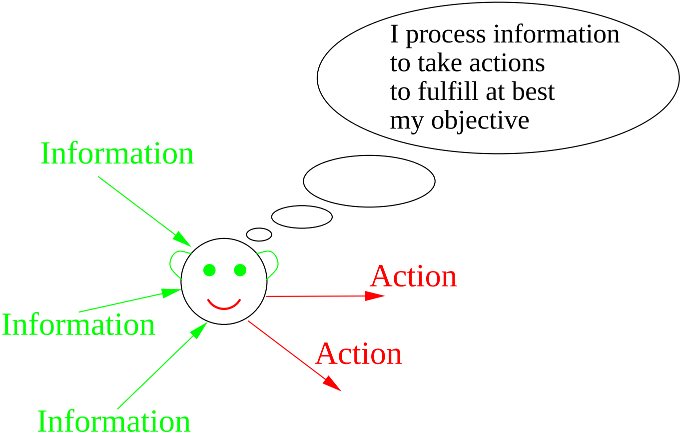
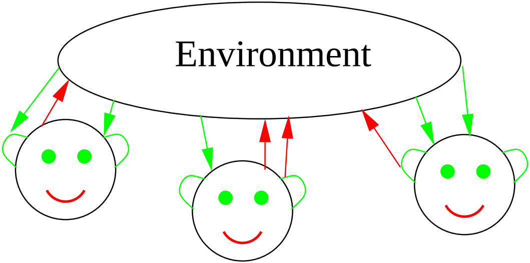
An objective oriented agent

An objective oriented agent is defined as an entity which processes information to select actions to fulfill at best its objective.



Systems driven by objective oriented agents

We are interested to analyze/control the dynamics of system driven by objective oriented agents.



Many practical problems are concerned (policy making, playing successfully in a market, ...)

Two approaches to analysis/control

An agent-based approach

1. the learning mechanism of each agent is modeled (reinforcement learning algorithms, best response strategies, etc)
2. the agent models are put together to build a model of the whole system
3. the system is simulated and analyzed

An equilibria-based approach, mostly computation of Nash equilibria and their refinements.

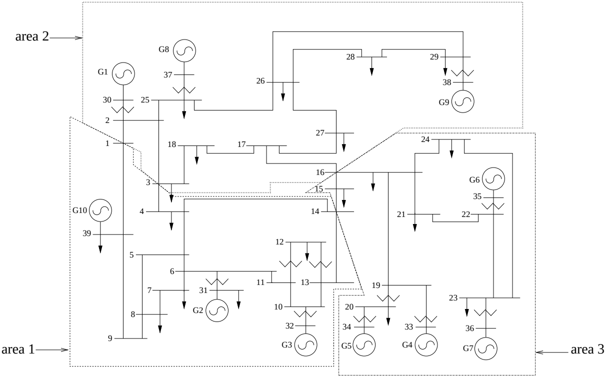
So many open questions...

- *Validation of the models*
  1. processing of real life data
  2. design of experiments to generate data
- *Convergence of the simulated system to a Nash equilibrium*
  1. strong results in the framework of repeated games and multi-agent Markov Decision Processes when state and action spaces are finite
  2. justify the perfect information assumption done when computing Nash equilibria
  3. what if many equilibria ? (switching from one equilibrium to the other, convergence to the best equilibria, ...)
- *What about the control aspects ?*

Power systems and objective oriented agents: overview of our work

On multi-area control in electric power systems (PSCC 2005)

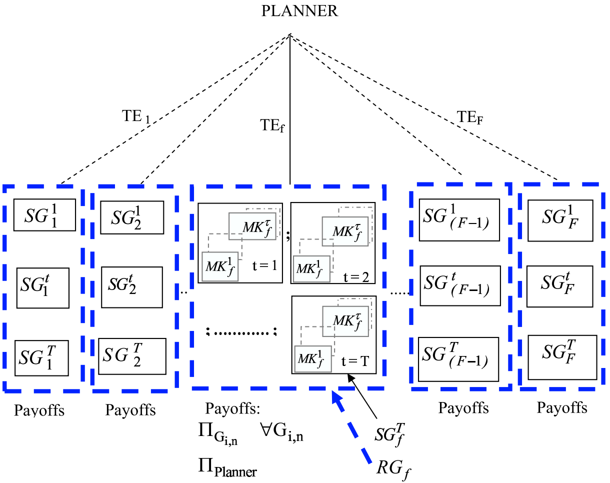
- Motivation: Understand better the impact of the sharing of information between TSOs on power system security. We considered the particular problem of maximization of the reactive power reserve.
- Methodology::
  - Each TSO is an objective oriented agent who wants to maximize the reactive power reserve within his own area
  - Agent-based approach with models of the type best response
  - The best response of an agent depends on the amount of information he has on other areas of the system.
- Main outcome of the work: Poor security level may be attained when the different TSOs exchange their information about their area dynamics without coordinating their actions.



Dynamics description	Reactive power produced
Partial information	12.119
Full information	15.674
No dynamics (reactive power prod. when voltage set points equal to 1)	13.589
Centralized optimization	12.116

Social planner reference network: a game theory approach (IEEE Transactions on Power Systems 2006)

- Motivation: To define an optimal network (from a social point of view) to be used as benchmark for the approval or the rejection of a given transmission expansion plan
- Methodology:
  - Locational marginal price structure for the market
  - One objective oriented agent per power producer plus one objective oriented agent for the social planner
  - Power producer agents can submit bids to the spot market and the social planner takes "transmission investment actions".
  - Computation of a subgame perfect Nash equilibrium
- Outcome of the work: an algorithm to compute an optimal network in a deregulated environment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A comparison of Nash equilibria analysis and agent-based modeling for power markets (PSCC 2005)

- Motivation: To better understand the inner relationships that exist between an agent-based approach and a equilibria-based approach in the context of electricity market analysis
- Methodology:
  - Locational marginal price structure for the market
  - One objective oriented agent per power producer. Power producers bid to the spot market to maximize their payoff.
  - a Q-learning algorithm is used to model the learning mechanism of the power producers
- Outcome of the work:
  - One single Nash equilibrium: the simulated system converges to this equilibrium
  - Many Nash equilibria: more complex system dynamics; the system may oscillate between the different equilibria