First ELECON Workshop
Towards Efficient European and Brazilian Electricity Markets

Tiago Pinto

tmcfp@isep.ipp.pt
tiago.m.pinto@gmail.com

ISEP, Porto, Portugal

25th September 2013

ELECON

ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

INSTITUTO POLITÉCNICO DO PORTO

gecad

Knowledge Engineering and Decision Support Research Center

An Electricity Market Simulator with Strategic Players

ELECON
ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

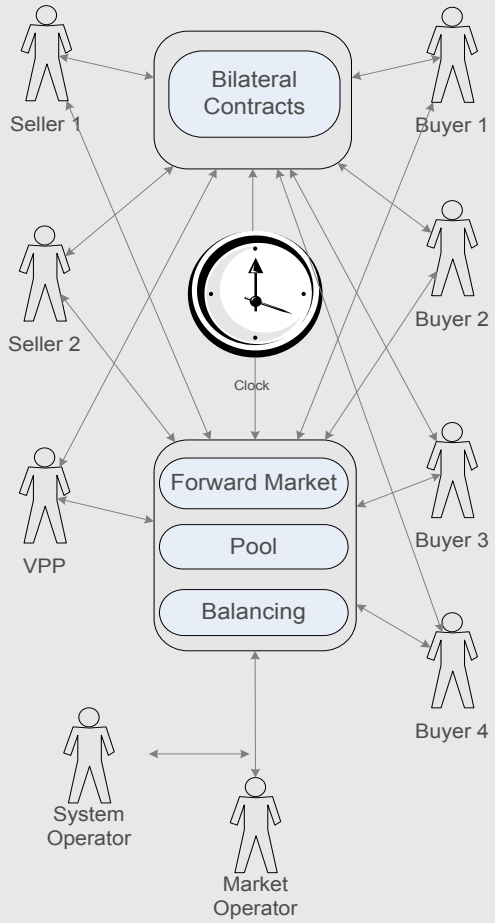
Outline

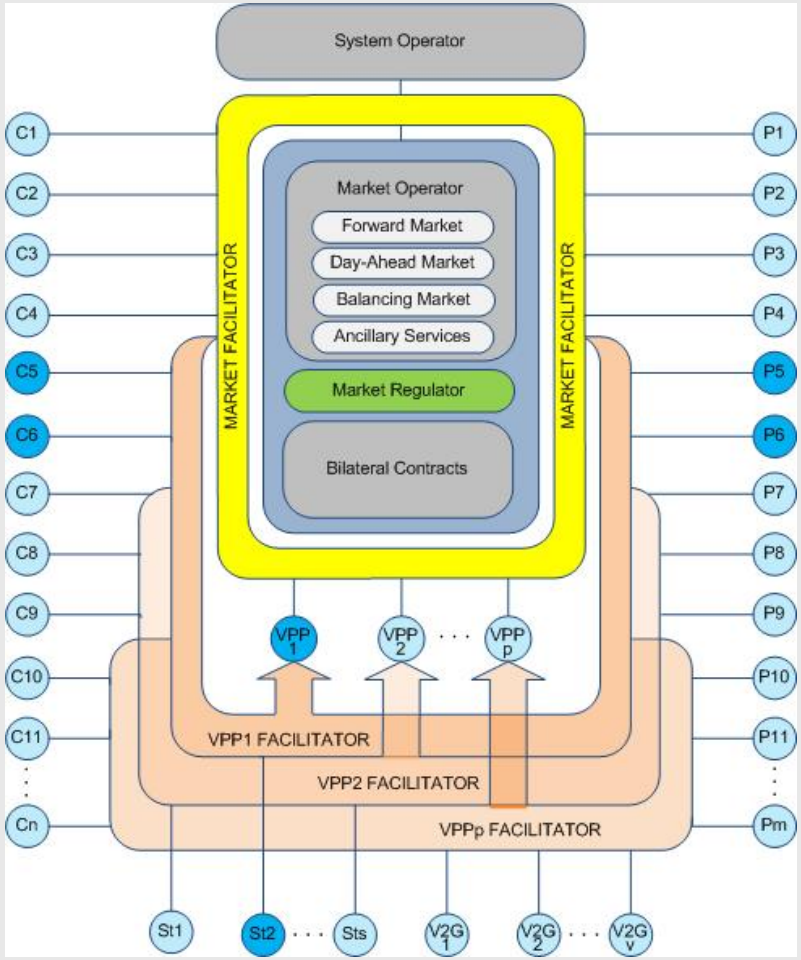
- **MASCEM simulator**
- **ALBidS decision support system**
  - **Multiagent architecture**
  - **Modules**
  - **Strategy Agents**
- **Demonstration**

ELECON

ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

MASCEM

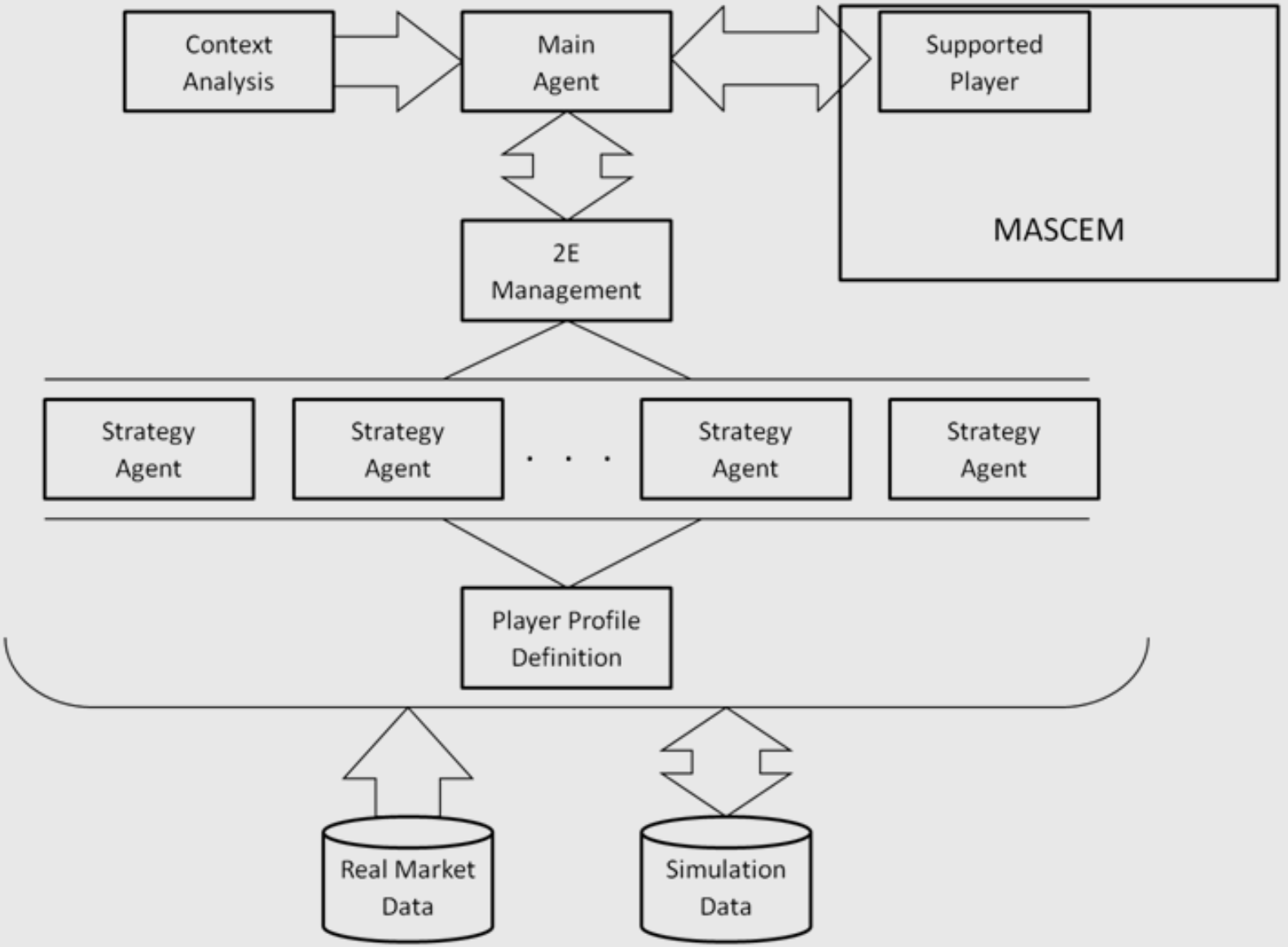




Isabel Praça *et al.*, 2003
"MASCEM: A Multi-Agent System that Simulates Competitive Electricity Markets"

Tiago Pinto *et al.*, 2009
"Multi-Agent Based Electricity Market Simulator with VPP: Conceptual and Implementation Issues"

ALBidS


Context Analysis
Main Agent
Supported Player
MASCEM
2E Management
Strategy Agent
Strategy Agent
Strategy Agent
Strategy Agent
Player Profile Definition
Real Market Data
Simulation Data

ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

ALBidS – Main Agent

- **Chooses, in each moment and circumstance, the action that presents the best expected results**

ALBidS - RLAs

- **Simple RLA**

$$C_{t+1} = C_t - \left|\left(R - P\right)\right|$$

- **Roth-Erev RLA**

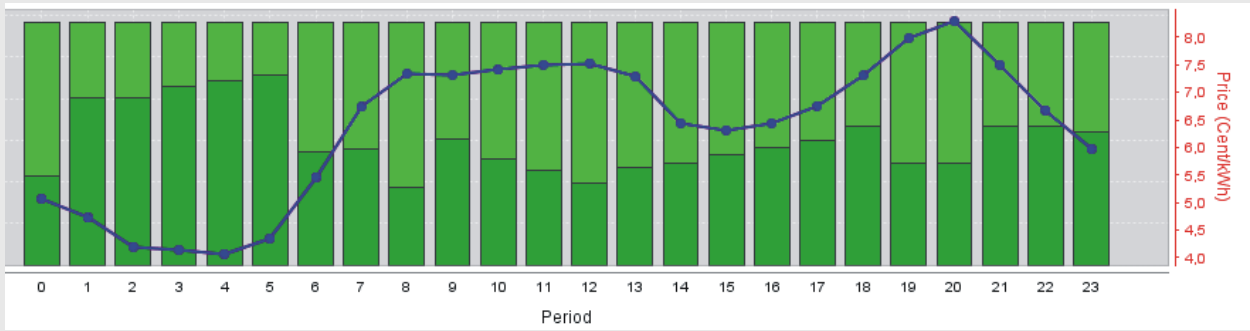
$$C_{t+1} = C_t \times W - \left|\left(R - P\right)\right| \times \left(1 - W\right)$$

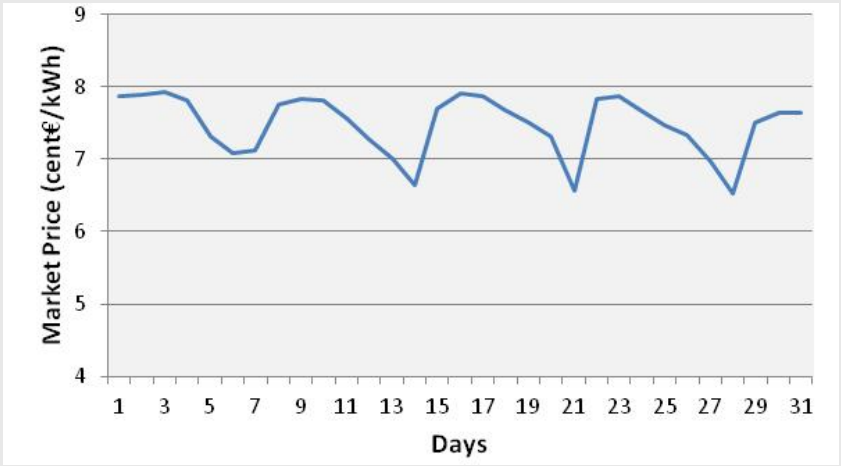
- **Bayes Theorem**

$$EU\left(A|E\right) = \sum_i P(O_i \mid E, A) \times U(O_i \mid A)$$

ALBidS – Context Analysis

- Analyses characteristics and particularities of each event
- Allows adapting the negotiation approach, adjusting the actions to the context in which they occur





ALBidS – Context Analysis

- Analyses the characteristics of days and periods
- Clustering of situations with similar characteristics, taking into account, for each period of each day:

		Period					
		7	8	9	10	11	12
Day	1	D1 P1	D1 P1	D1 P1	D1 P2	D1 P2	D1 P2
	2	D1 P1	D1 P1	D1 P1	D1 P2	D1 P2	D1 P2
	3	D1 P1	D1 P1	D1 P1	D1 P2	D1 P2	D1 P2
	4	D1 P1	D1 P1	D1 P1	D1 P2	D1 P2	D1 P2
	5	D1 P1	D1 P1	D1 P1	D1 P2	D1 P2	D1 P2
	6	D2 P1	D2 P1	D2 P1	D2 P2	D2 P2	D2 P2
	7	D2 P1	D2 P1	D2 P1	D2 P2	D2 P2	D2 P2
	8	D1 P1	D1 P2	D1 P3	D1 P2	D1 P2	D1 P2

- Market price
- Amount of power
- Wind power
- Type of day
  - Business day
  - Weekend
  - Special situations

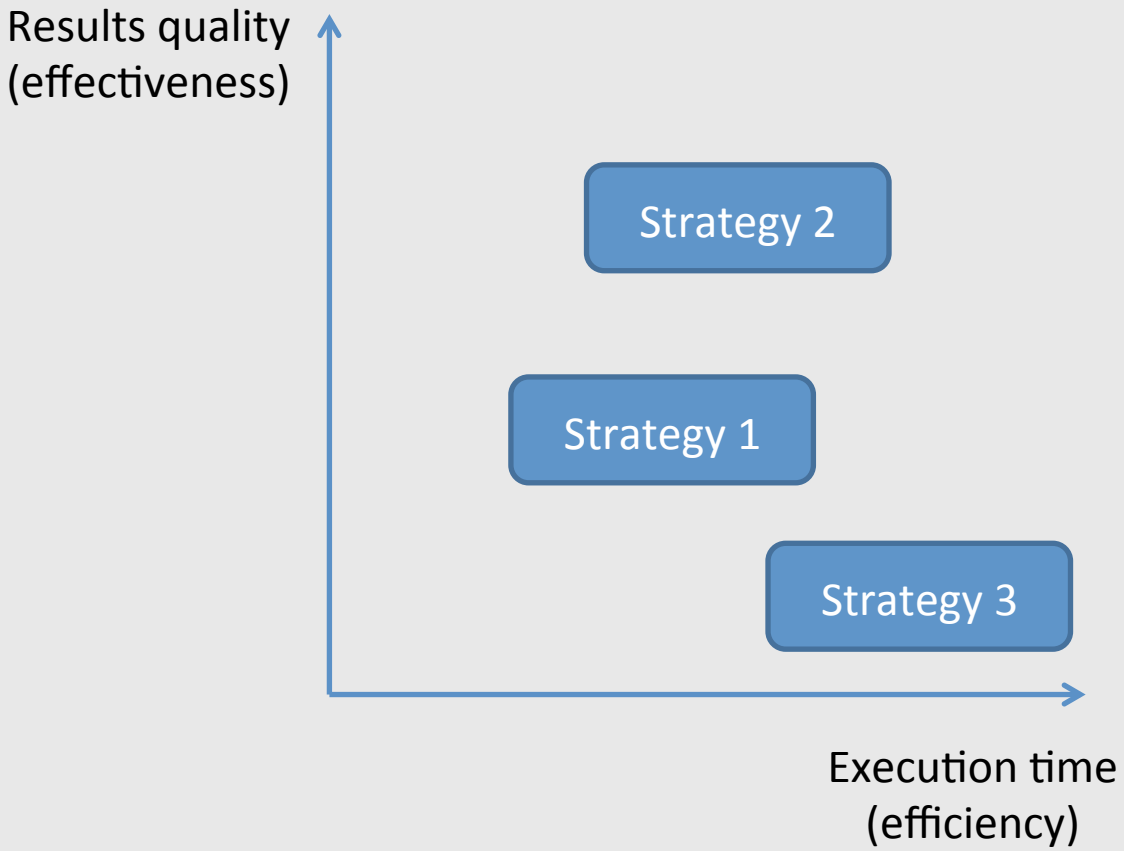
ALBidS - 2E Management

- Many algorithms running simultaneously
  - Different execution times (Efficiency)
  - Different forecast Effectiveness
- Need for dynamic management of the system's efficiency/ effectiveness balance
- User defines the relative importance of the Efficiency and Effectiveness for the simulation

- 100% importance for effectiveness:
  - All algorithms are executed at the maximum at their capabilities
- 100% importance for efficiency:
  - Algorithms with higher execution time than MASCEM's simulation are excluded, only remaining the faster ones

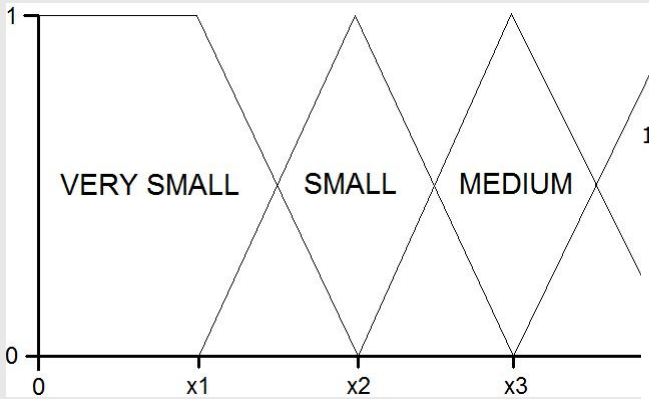
ALBidS - 2E Management

- **Choosing an intermediate percentage requires a careful and intelligent analysis of the balance between the efficiency and the effectiveness**

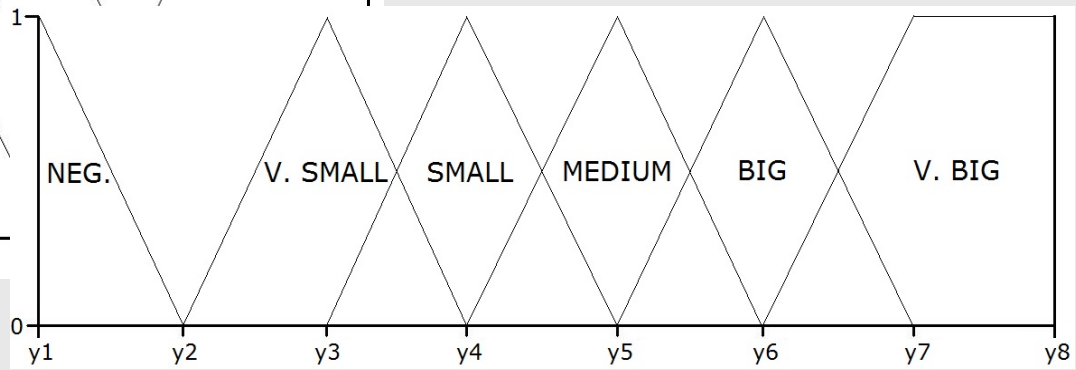


- **Two Fuzzy variables with dynamically defined intervals**

Effectiveness



Efficiency



- **Confusion matrix combines the two fuzzy variables with the user preference**

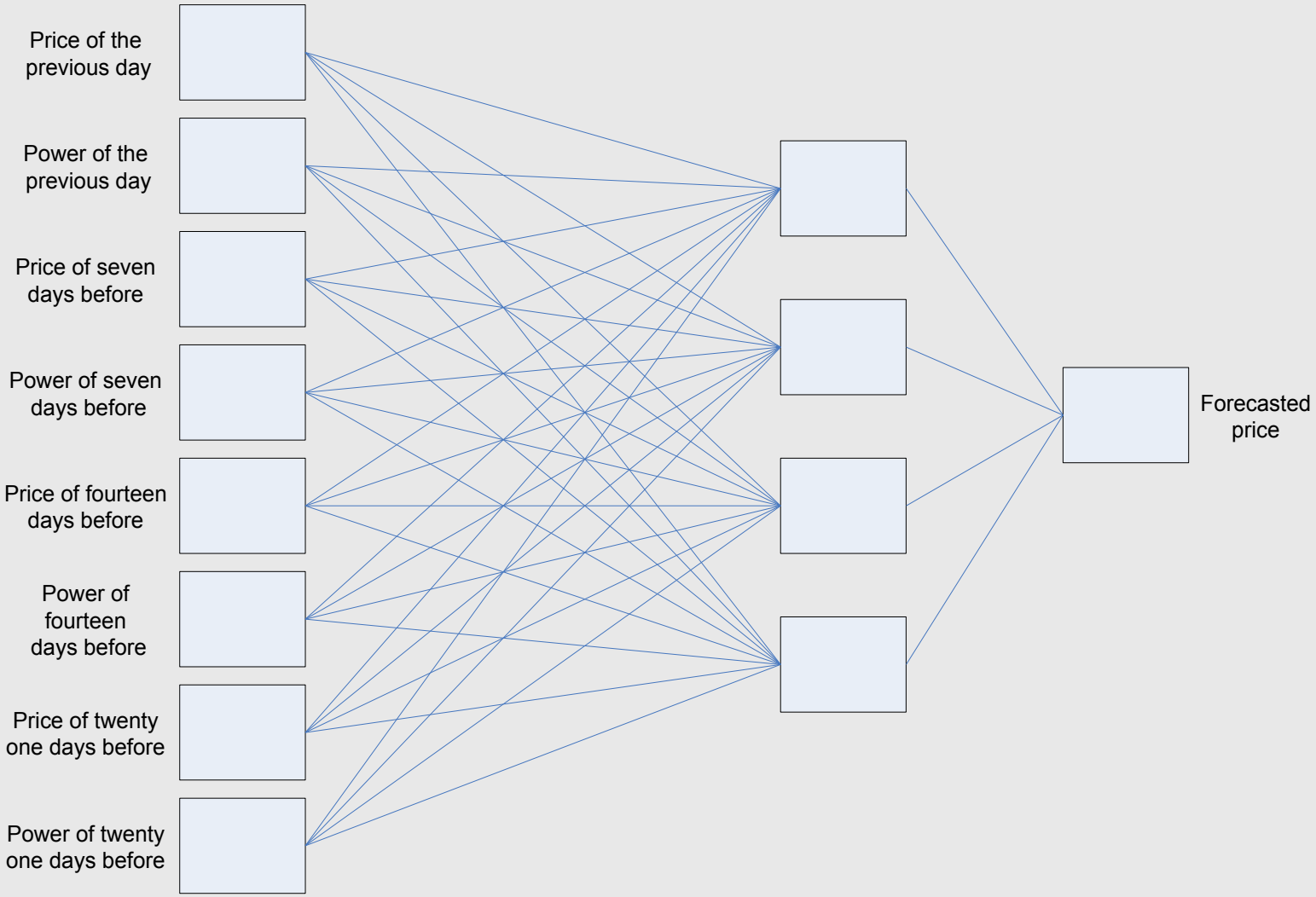
- **Determines if each algorithm:**
  - **Is excluded from the simulation**
  - **Must reduce its execution time by a large or small amount**
  - **Is using an adequate amount of time, being executed at the best of its capabilities**

ALBidS – Strategy Agents

- Composed Goal Directed
- Adaptive Derivative Following
- Market Price Following
- Average and Regression:
  - Business bays
  - Previous week
  - Previous month
  - …

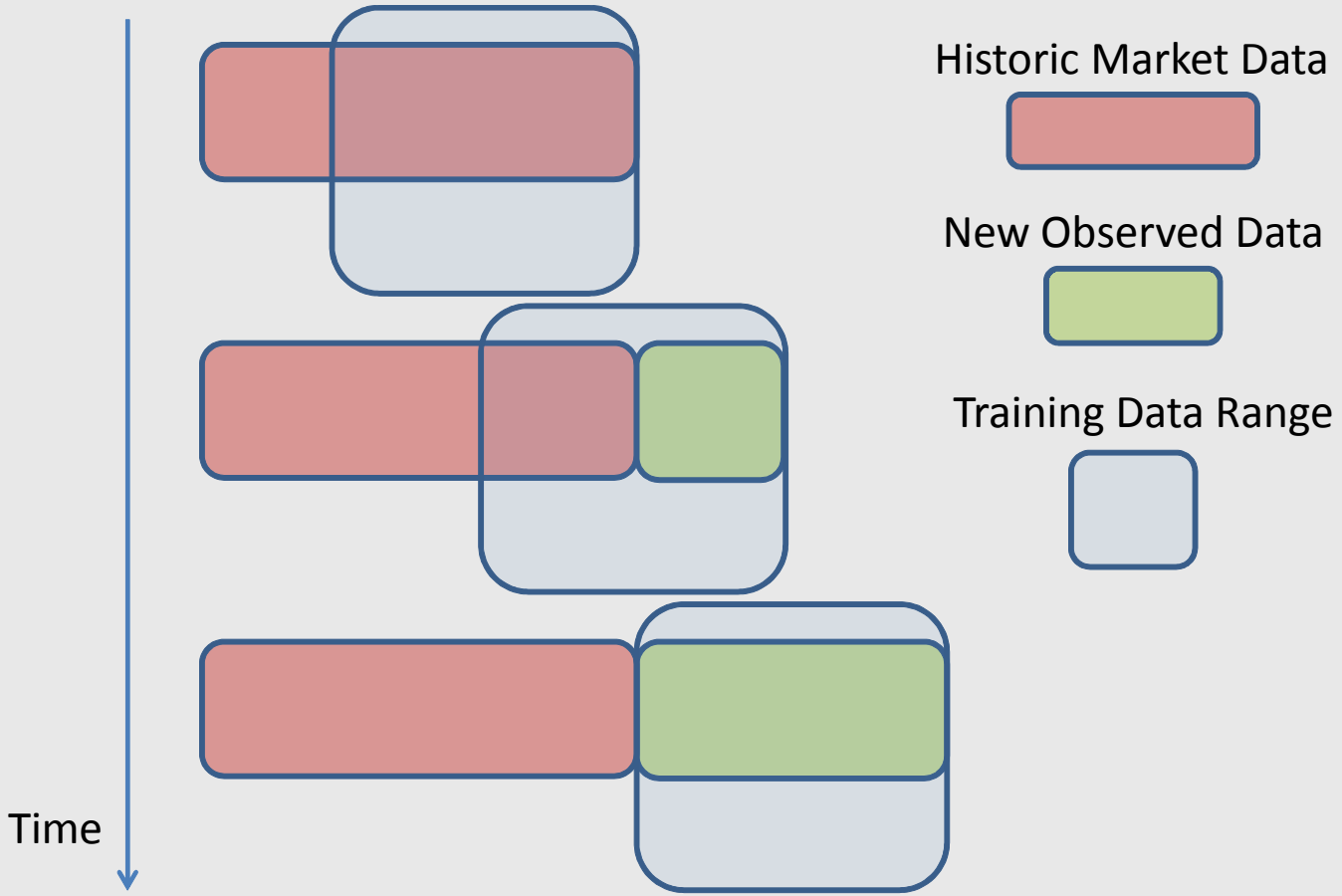
ALBidS – Strategy Agents

- **Dynamic Artificial Neural Network Agent**



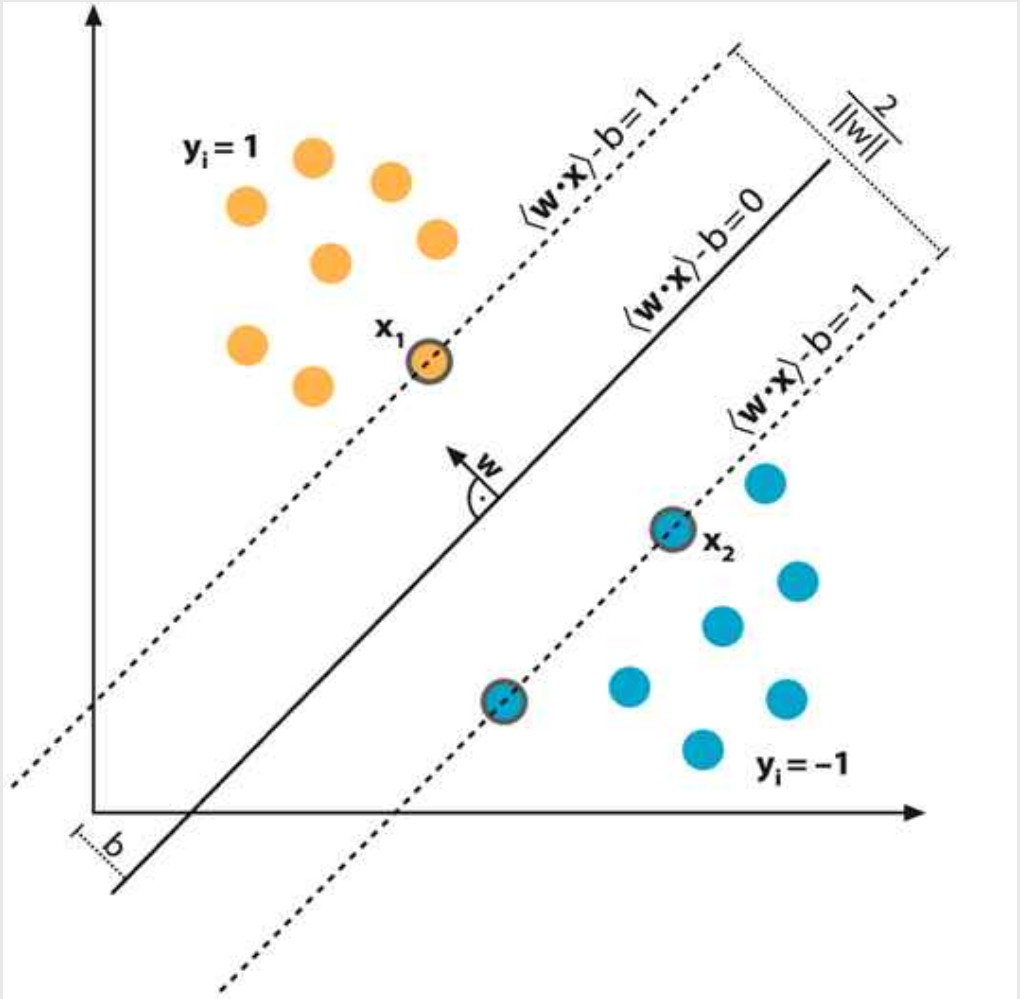
ALBidS – Strategy Agents

- **Dynamic Artificial Neural Network Agent**



ALBidS – Strategy Agents

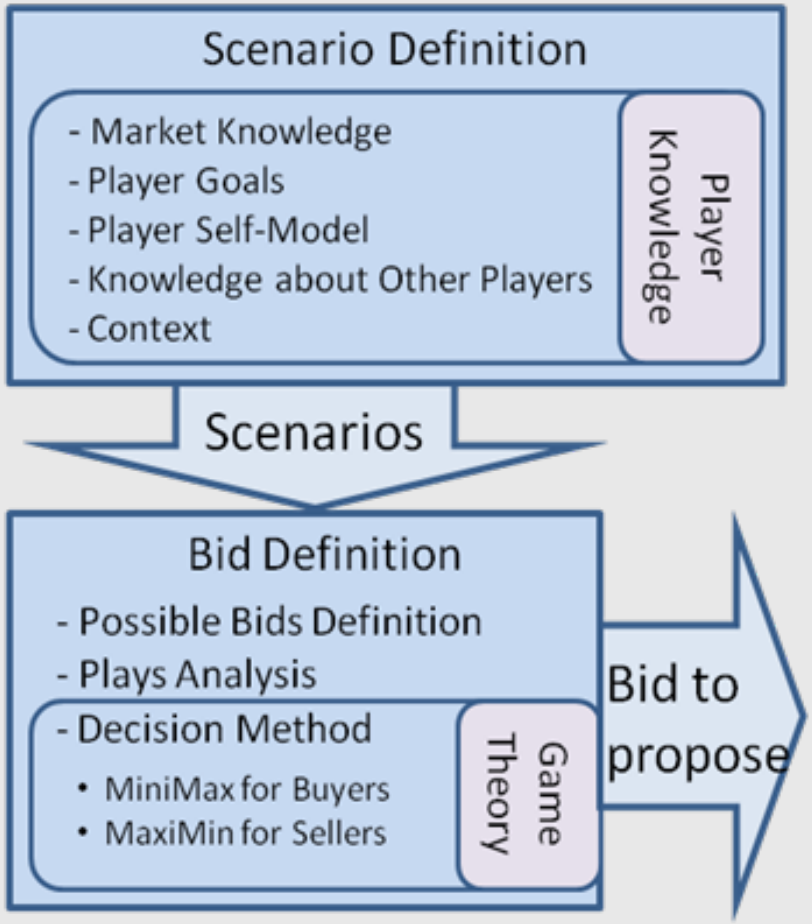
- **Support Vector Machine Agent**



ALBidS – Strategy Agents

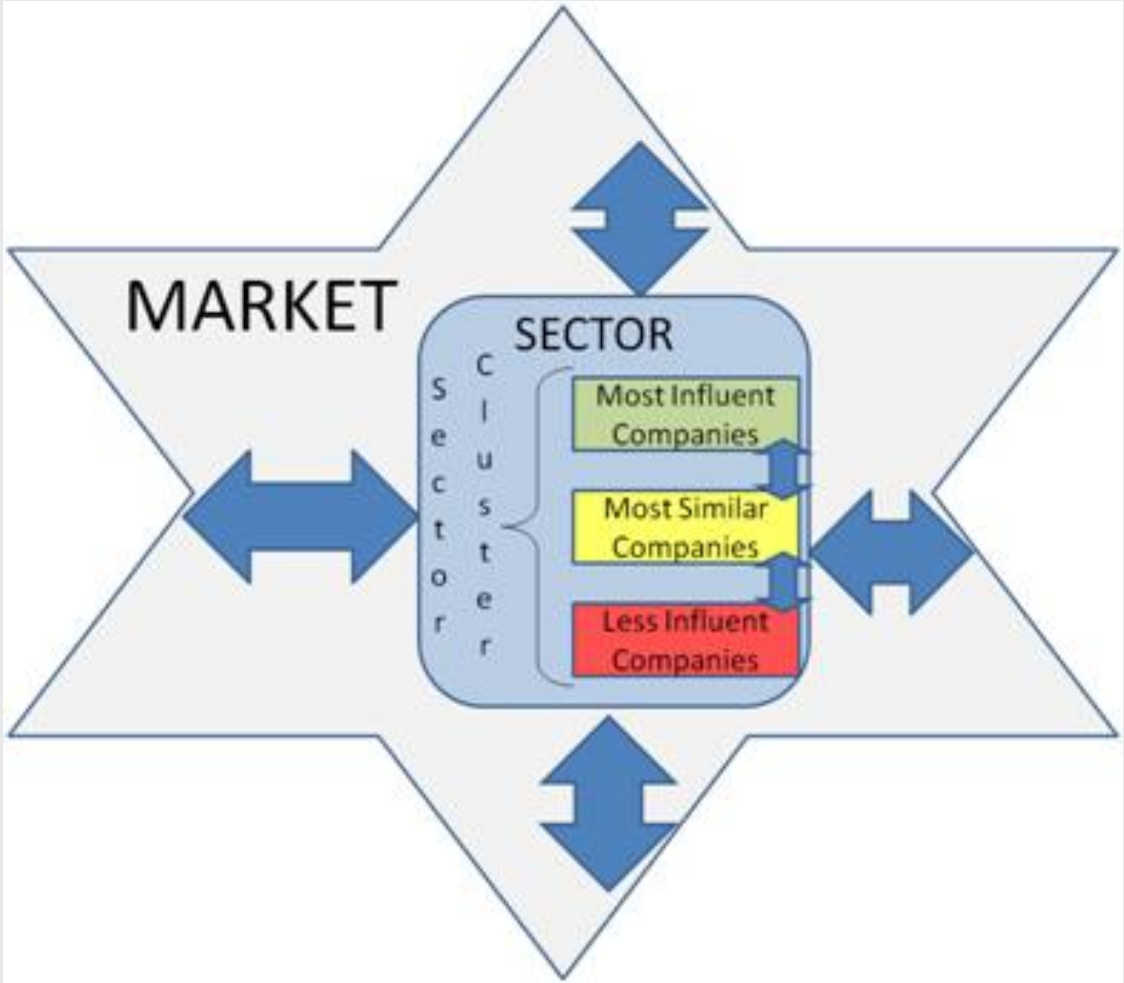
- **Game Theory Agent**

Scenario Analysis algorithm based on the application of the game theory (Minimax/Maximin)



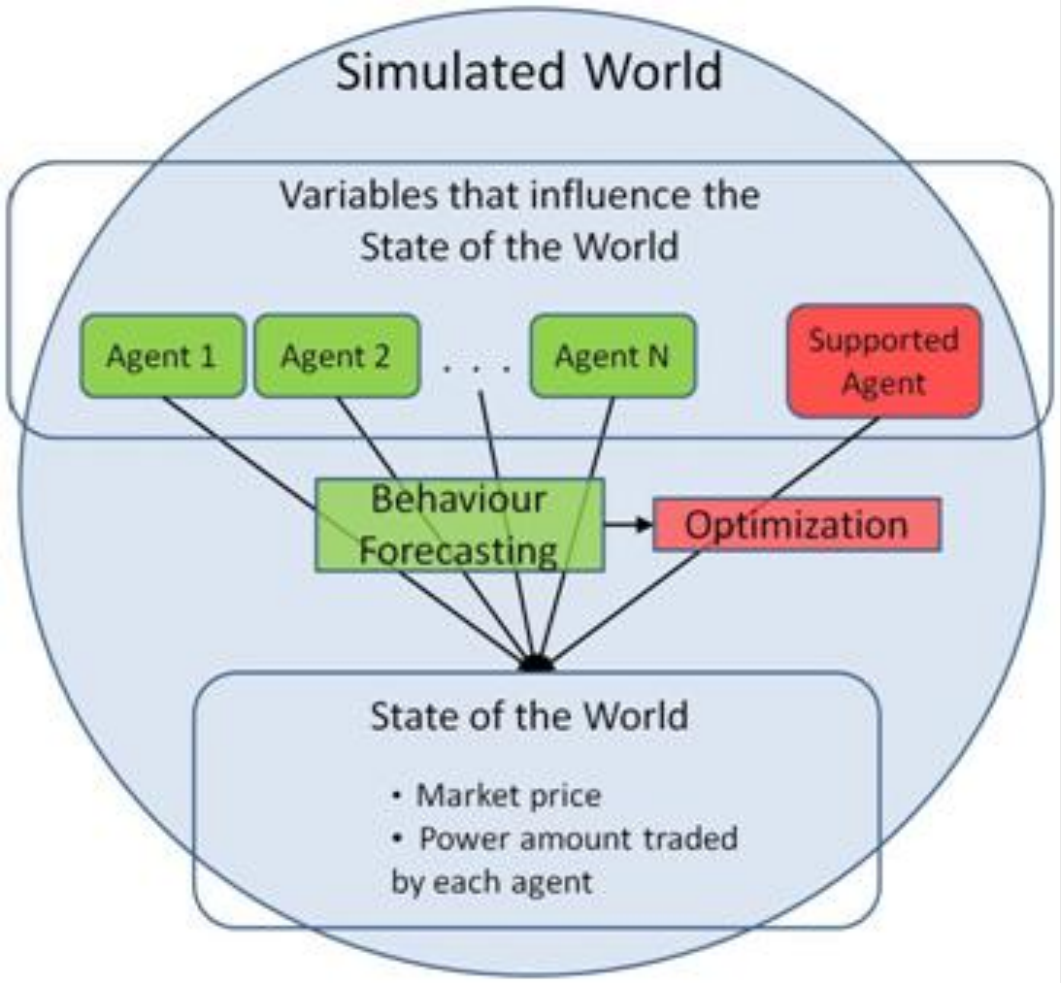
ALBidS – Strategy Agents

- **Economic Analysis Agent**



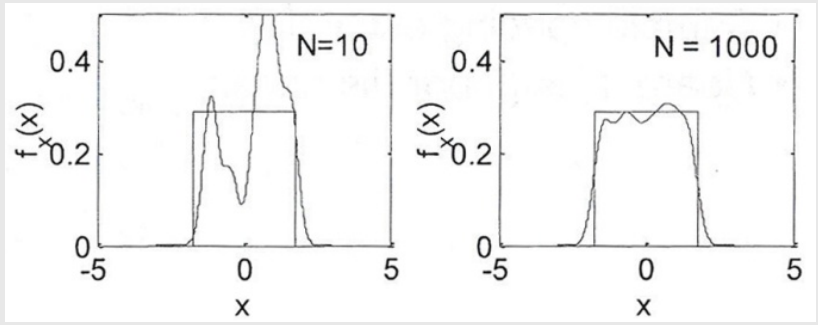
ALBidS – Strategy Agents

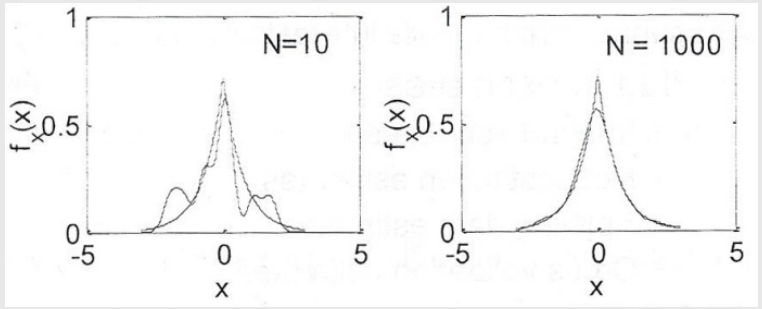
- **Determinism Theory Agent**

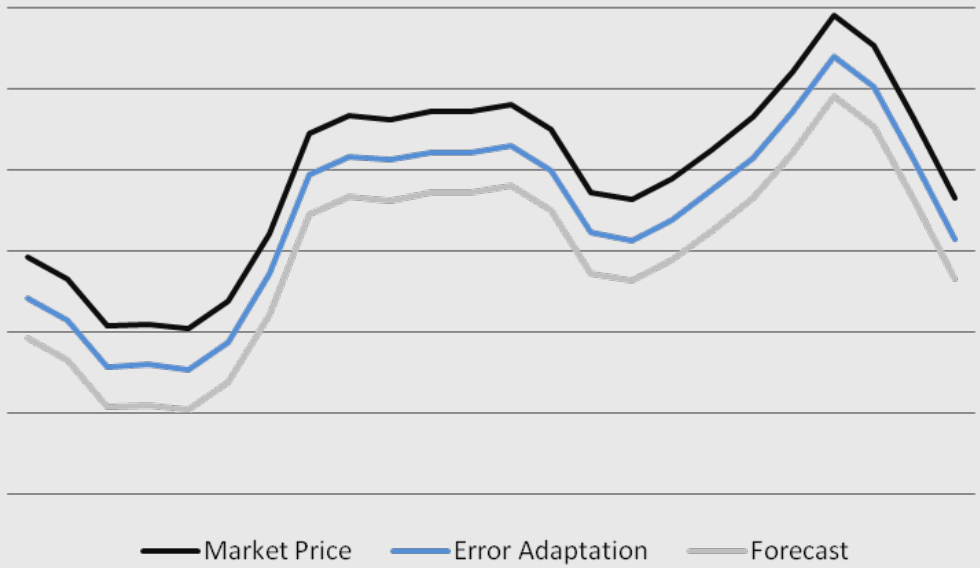


ALBidS – Strategy Agents

- **Error Theory Agent**







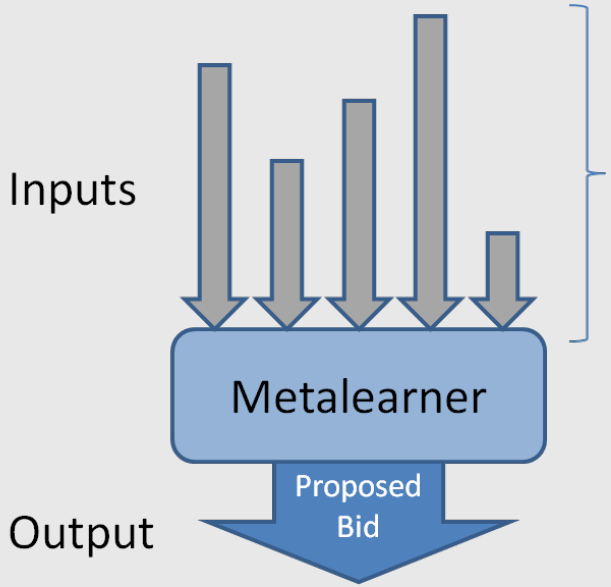
ALBidS – Strategy Agents

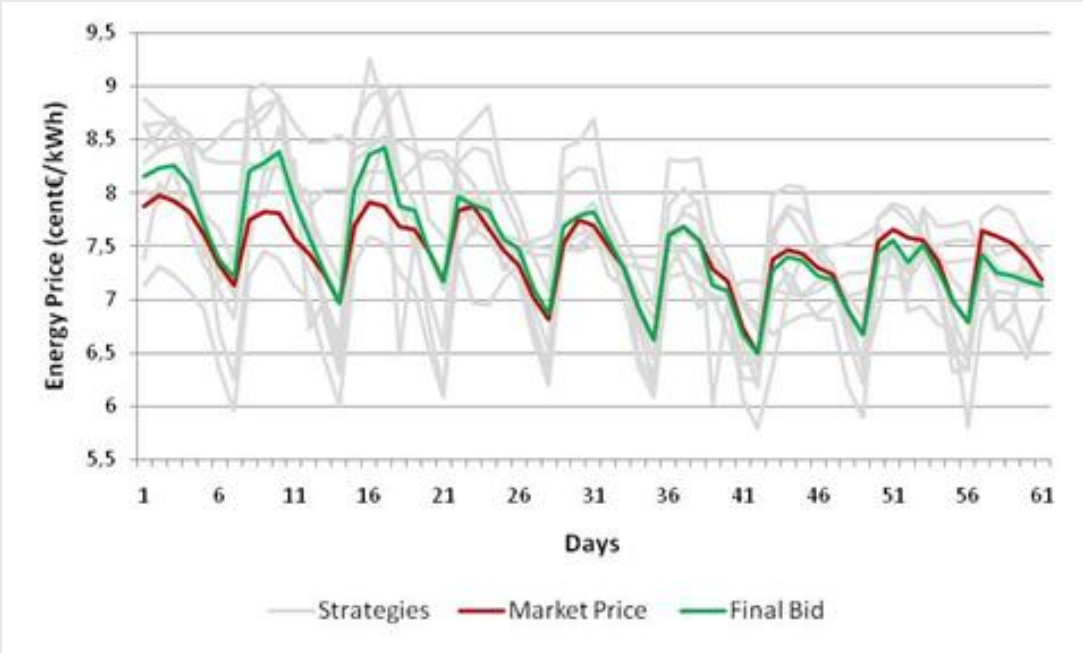
	AMES	SA-QL
Possible actions definition	Analysis of production costs	Directed to the most likely points
Algorithm for choosing the best action	Roth-Erev	Q-Learning
Convergence process acceleration	Simulated Annealing	

Li and Tesfatsion, 2009
"Development of Open Source Software for Power Market Research: The AMES Test Bed"

ALBidS – Strategy Agents

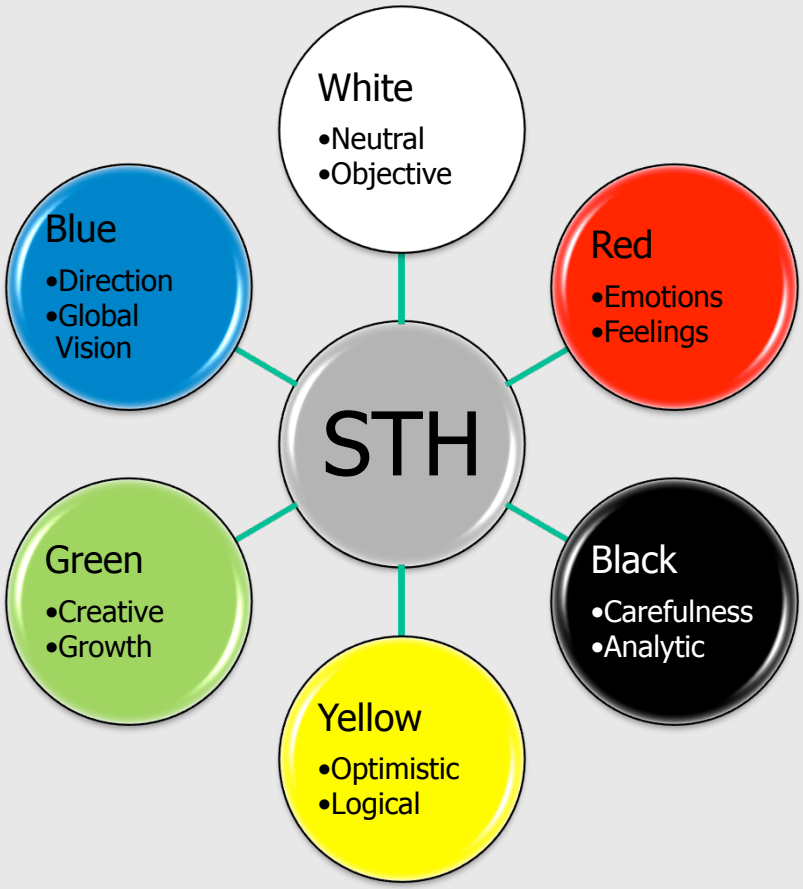
- **Metalearner Agents**





ALBidS – Strategy Agents

- **Metalearner Agents**
  - **Simple Metalearner**
  - **Weighted Metalearner**
  - **ANN based Metalearner**
  - **Six Thinking Hats**



ALBidS - Players profiles

- Some strategies used in ALBidS require players models
- The models are defined analogously to the previously presented methodology
  - There is a reinforcement learning algorithm that chooses the answer that is more likely to give the best prediction of the player next action, from a set of diferent proposals from distinct algorithms

ALBidS - Players profiles

- **Reused Algorithms:**
  - **Dinamic Feed Forward Artificial Neural Network**
  - **Algorithms Based on Statistical Aproaches**
- **Algorithms based on actions pattern analysis**
  - **Sequences in the past matching the last few actions. The longer matches to the recent history are attributed an higher importance**
  - **Most repeated sequence along the historic of actions of this player**
  - **Most recent sequence among all the found ones**

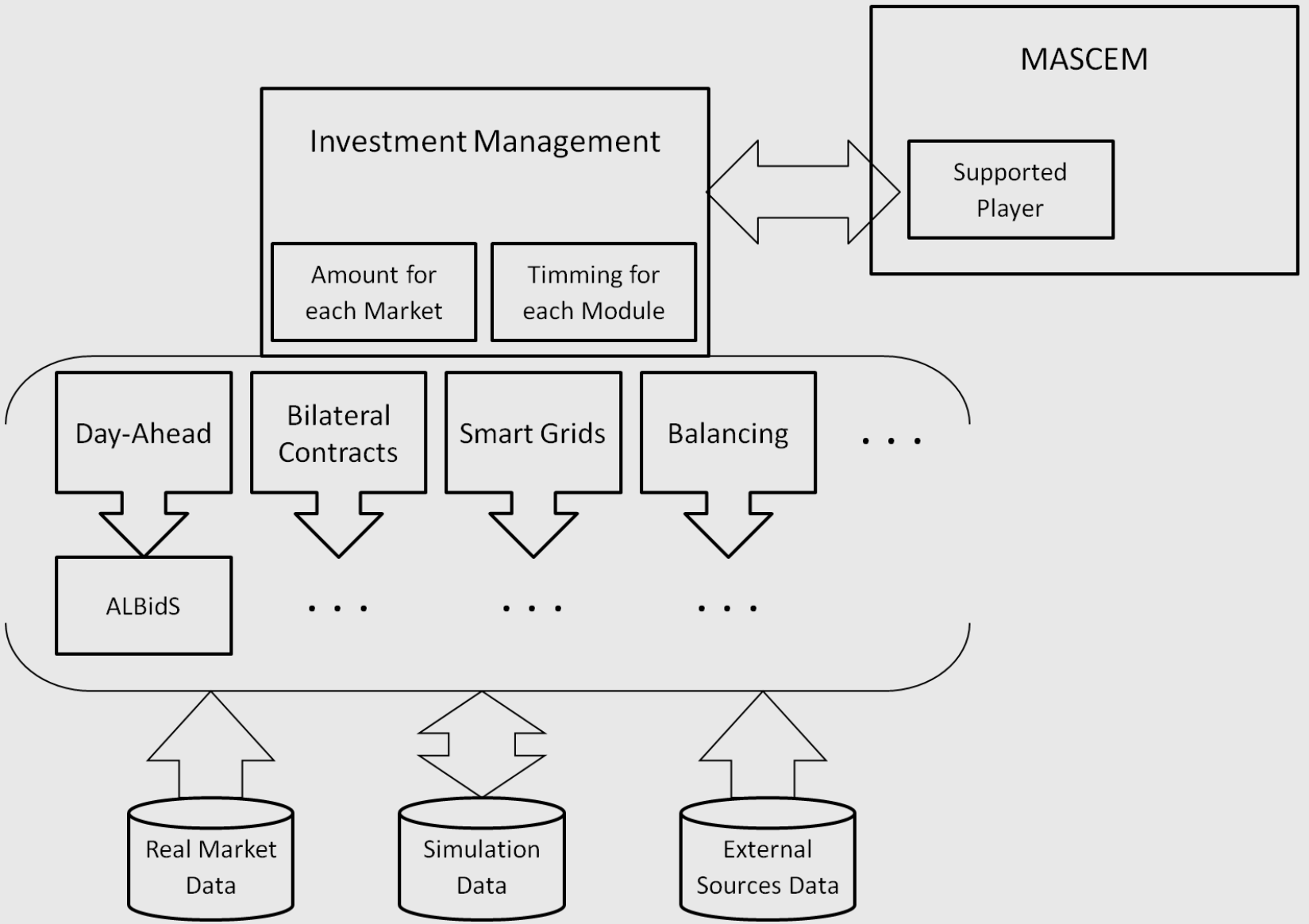
ALBidS - Players profiles

- Algorithm based on history matching
  - Regarding not only the player actions, but also the result they obtained
  - How the player reacted, the last time he performed the same action and got the same result
- Algorithm returning the most repeated action of this player
  - This is an efficient method for players that tend to perform recurrent actions

ALBidS - Players profiles

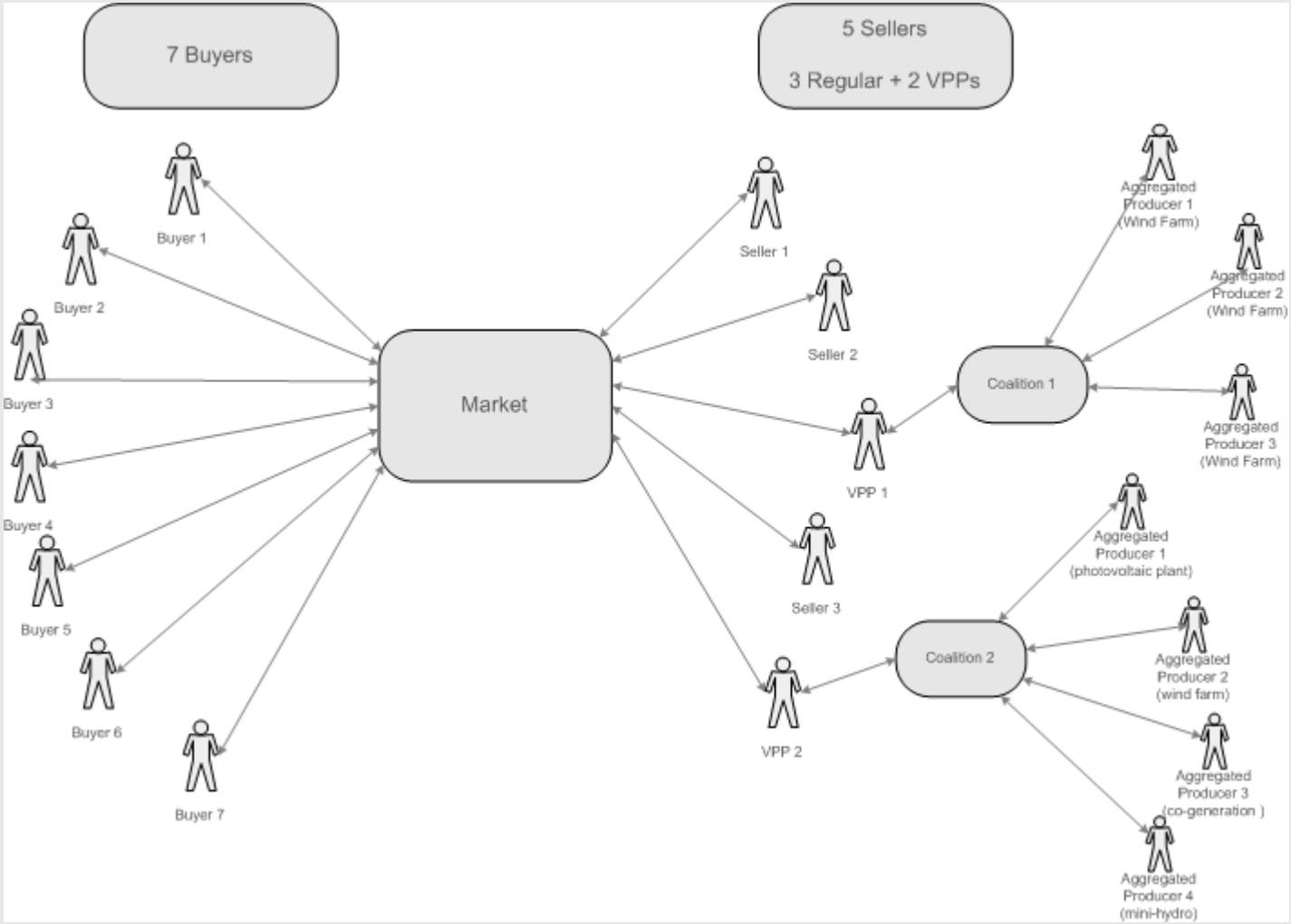
- Second Guessing the predictions
  - Second-Guess
  - Third-Guess
- Self Model prediction
  - analysis on its own historic of actions, to predict what itself is expected to do next
- Second-Guess the Self Model prediction

ALBidS Evolution



ELECON
ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

Demonstration Scenario



ELECON

ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

Demonstration

INSTITUTO POLITÉCNICO DO PORTO

gecad Knowledge Engineering and Decision Support Research Center

First ELECON Workshop
Towards Efficient European and Brazilian Electricity Markets

Tiago Pinto

tmcfp@isep.ipp.pt
tiago.m.pinto@gmail.com

ISEP, Porto, Portugal

25th September 2013