Energy Market

André Cruz
Edgar Carneiro
Xavier Fontes

Agents and Distributed Artificial Intelligence - AIAD
Faculty of Engineering
University of Porto
2018

Problem Description

Our work focused on simulating an **energy market**. This market has three key players, the **Producers**, the **Brokers** and the **Consumers**.

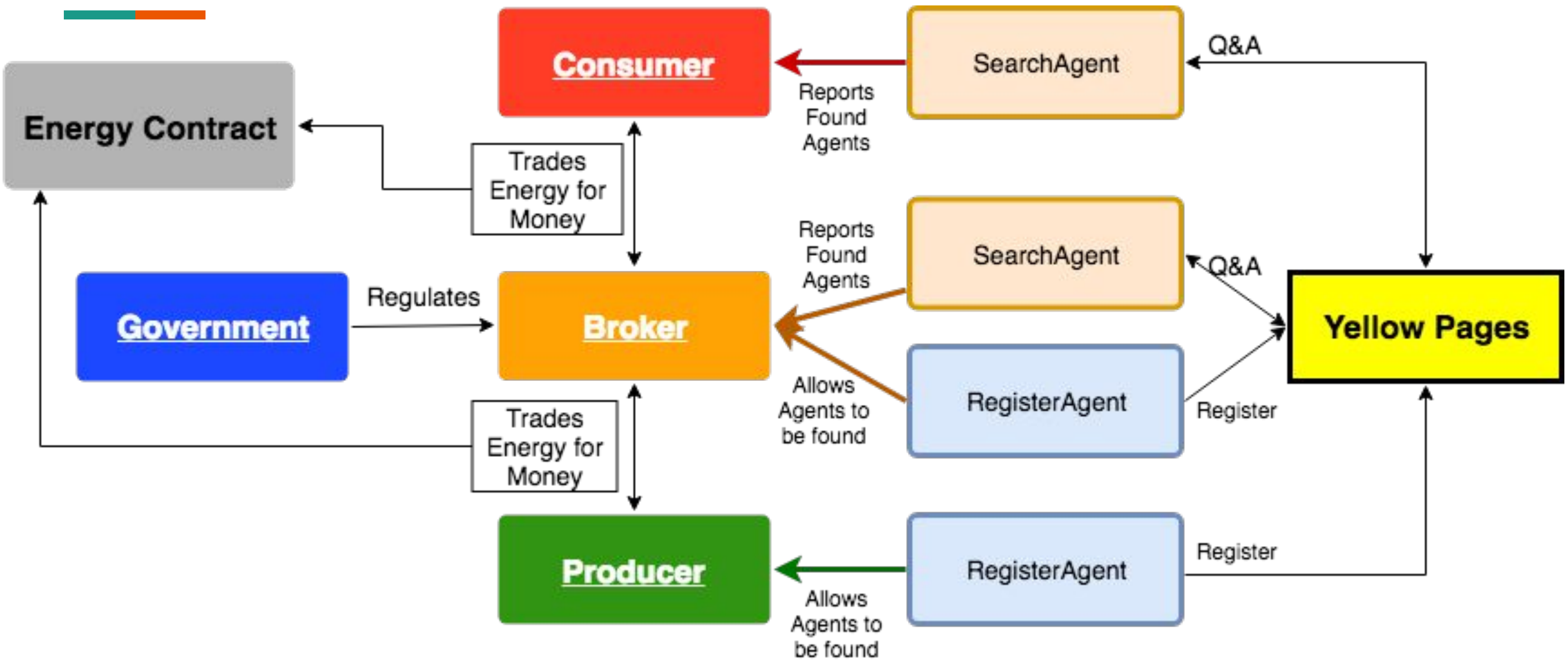
Each **Producer** has an energy source associated and this energy can be **Renewable** or **Non-Renewable**.

Each **Broker** buys energy from one or more **Producers**, and sells it to multiple **Consumers** at a profit.

Each **Consumer** buys energy from one **Broker**, and may prefer to contact Brokers with **lower prices**, Brokers that are **physically closest** to it, or Brokers with a prevalence of **renewable energy sources**.

Exchanging Energy for Money is made by signing an **Energy Contract**, which is breached if any part fails to fulfill their part (either by lack of energy or money).

Agents Structure in the Energy Market



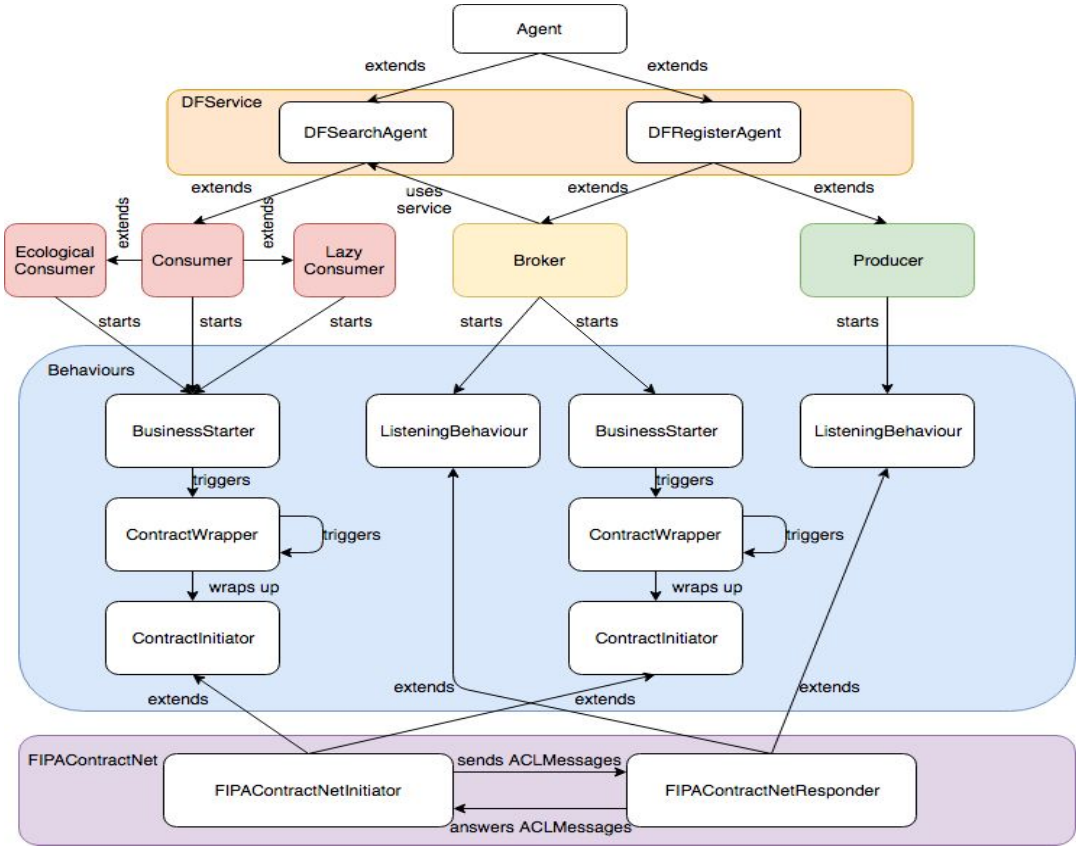
Interaction and Protocols

Producers and **Brokers** are registered in JADE's **Directory Facilitator**.

Brokers search for **Producers** to supply them with energy and **Consumers** do the same thing with respect to **Brokers**. These searches are made using the **Directory Facilitator**.

FIPA contract nets are used when any agent is trying to get a supplier of energy and during this phase **Energy Contract Proposals** are exchanged. If both parties agree to the Contract Proposal, an **Energy Contract** is signed, committing both parties to exchange energy for money.

Agent Architectures and Strategies Used



Other Mechanisms - Finding the Suppliers

The **Brokers** search for **Producers** to supply them with energy. The **Consumers** search for **a single Broker** to supply them with the energy they need to consume. This **search** is made by using the **Directory Facilitator** mechanism present in JADE.

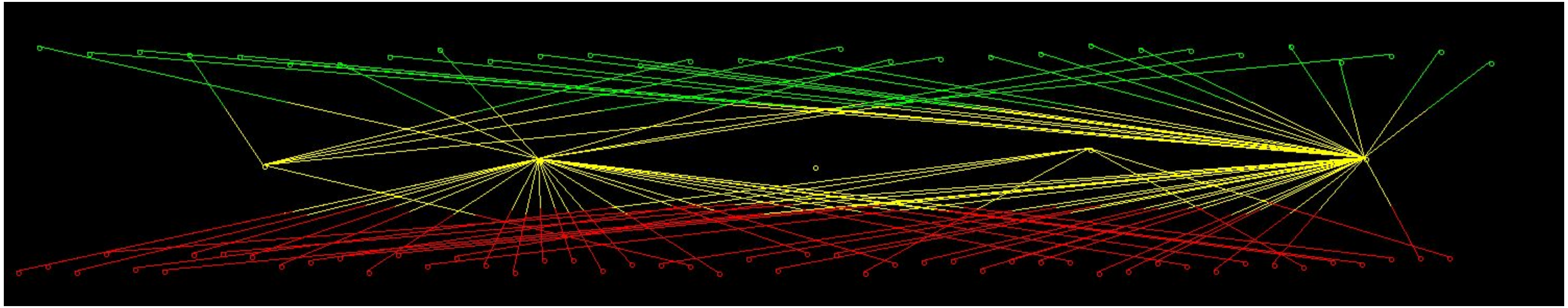
Producers and **brokers** need to be **registered** in the Directory Facilitator service so that the agents wanting to trade with them can find them. Therefore, they both extend **DFRegisterAgent,** the agent that is responsible for self-registering in the service **.**

In order for **Brokers** and **Consumers** to be able to **search** for the other agents, they both extend **DFSearchAgent.**

Software Used

To implement this model and run the experiments we used **JADE** together with **Repast3** with the **SAJaS**.

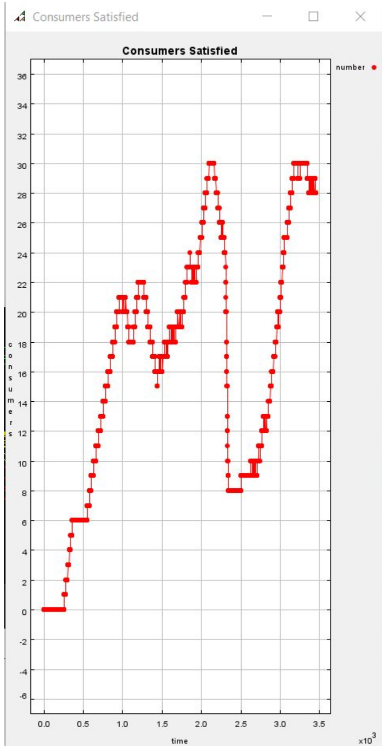
The three main protagonists of our simulations implement the **Drawable** interface that allows them to be drawn on a display surface. At **each tick** in the simulation, which by convention we consider a **day**, we also draw the connections **Producers-Brokers** and **Brokers-Consumers** to have a general idea of the behaviour of the market. (**Producers**, **Brokers**, **Consumers**)

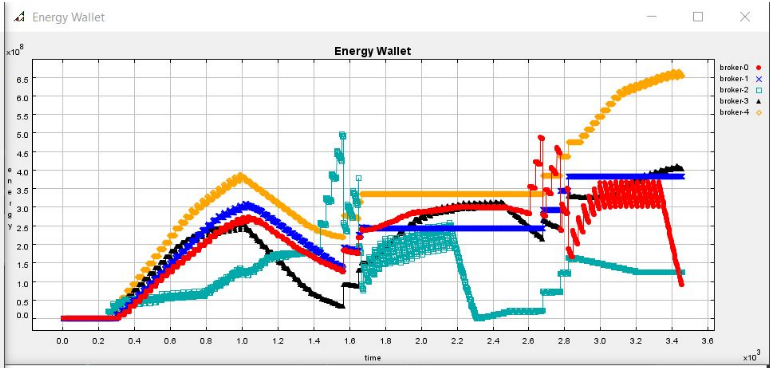


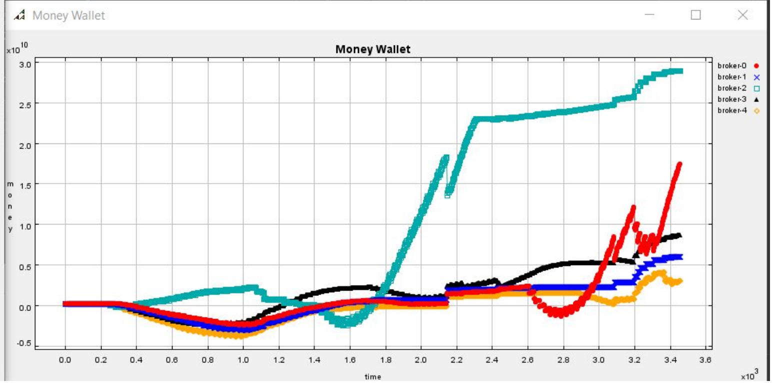
Experiments

Our current experiments are being done with **50** producers, **5** brokers, **30** consumers and a government that, on average, checks for a broker monopoly (**50%** or more of the total energy sold) every **90 days**.

These five parameters, as well as the percentage of each type of Consumer, can be freely adjusted to test new situations.







Result Analysis

During the development of the project we started to see the effects of the parameters imposed on the model. For example, the **duration of the contracts** versus the **time to exchange messages** is a deciding factor for achieving a **high consumer satisfiability**. When the **Government** agent is not present, one of the **Brokers**, given enough time, often manages to form a monopoly by making contract with most of the **Producers**.

The market can achieve close to 100% consumer satisfaction, under certain circumstances. Additionally, Brokers can successfully compete with each other by lowering/increasing prices.

Over time, the **Brokers**' energy and cash wallet can be used to see if it is in fact **supplying energy** to someone (its **cash increases** and **energy decreases**), if it's supplying energy that it has **stored** (its **energy decreases** and **money increases**), or if it is buying and selling energy at approximately the same rate (energy **stabilizes**, and money slightly increases).

Conclusions

The group is pleased with the resulting project, as simulating an energy market poses a difficult challenge, featuring **multiple intervening agents** with **competing objectives**. It's interesting to note that **different market configurations** lead to **distinct results,** and we aim to identify the responsible factors.

Nonetheless, to replicate a real energy market we would need to develop a more accurate supply-demand equilibrium, which requires new agents to be created when the incentives are high, old agents to go bankrupt when incentives are low, and Consumers to be discouraged of consuming when prices are high, as well as multiple other interactions.

In future work, we'll carry out studies aiming to **maximize the number of satisfied consumers** by **tweaking the market's configurations**. Additionally, the introduction of new types of actors, with different preferences and behaviours, may greatly enrich the market. It would also be interesting to introduce agents capable of learning from their interaction with the market, and later study the final impact of these additions.