TUTORIAL: Programming agents in electronic institutions

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SOLUTIONS

Exercise 1

(i) how the market operates

This specification has got two performative structures: the MainPS and the DailyMarketPS. The first one is where trading agents get information about open markets. The second one is the market where consumers and producers trade energy. After an agent enters the eInstitution, he heads towards the information performative structure, and subsequently enters a market whenever he has energy to either sell or buy.

(ii) how producers and consumers interact with the rest of players in the market.

The available protocols in the DailyMarketPS are:

- Primary: where the consumers and producers participate in a double auction market. Each one sends his offer or demand to the system operator, who reports back to consumers and producers about the contracts that they are involved after clearing the double auction.

- Secondary: where consumers and producers engage in one-to-one negotiations. A consumer starts a negotiation by requesting a contract to some producer, who in turn can accept, refuse or send back an alternative request. If they reach an agreement, they report it to the system operator.

- Balancing: where the system operators guarantee that the consumers satisfy their demand. Thus, in this market the system operator assesses the overproduction per consumer as well as the consumers that must buy the energy.

Exercise 3

- What are the properties of the environment (world) for the institution?

The demand property identifies the forecast demand for the current market.

- What are the institutional properties?

a) power deficit percentage (PDP)
b) overproduction percentage (OPP)
c) power cost average (AvgC)
d) power cost deviation (DevC)
e) the demand of energy in the primary market (primaryDemand)
f) the offer of energy in the primary market (primaryOffer)

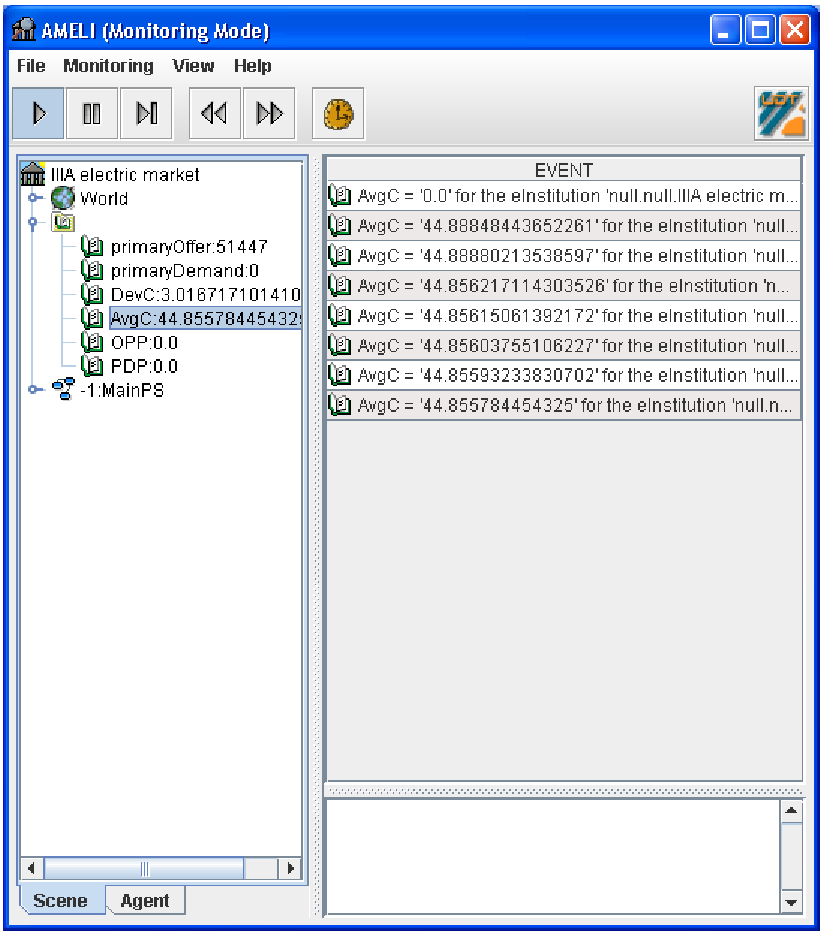
- Do the institutional properties change along the execution?

Yes, they change every time a new market starts.

Exercise 4

- Do you observe whether the power cost average (AvgC) stabilizes or else suffers from oscillations?

The average power cost is a straight line with a very smooth steep. When selecting the AvgC property in the monitoring tool we observe that the variation in prices is around 0.01.



- What is the percentage of energy sold in the double auction market?

Most of the time 100% of the energy is sold in the primary market. Therefore, the secondary and the balancing markets are not created. Also if you observe the demand curve, you can see that *primaryDemand* gets to 0.

- What is the effect of changing the demand model from working days to another model (namely holidays, Saturdays, and Sundays)?

When you change form working days to any other model, the demand decreases, leading the producers to generate more energy than necessary. As to AvgC, it does not suffer any relevant changes.

- If the average power cost stabilizes, do you observe whether the strategies of producers and consumers in the double auction significantly change?

You have to use the monitoring tool to analyse what agents say in the primary markets. You can use filters in the View menu to only show the messages sent by agents. Now you can observe that the variation between offer and demand prices are around 0.01 and 0.05 respectively. So the agents are too conservative. This explains why AvgC remains stable.

Exercise 5

- Is there any blackout in the market? If so, how would you avoid them?

Every time that the energy demand is greater than 30000 Kw/h a blackout comes about. You can visualise it in the demand chart because the primary demand is higher than the primary offer. Also notice that the OPP property of the institution is greather than 0.1 (10% of safe power!).

You could solve the blackout if you either add more producers or increase their maximum capacity so that they can produce more energy. In both cases it is necessary to set a greater powerUp and powerDown values, otherwise the producers cannot adapt to the changes in market demand.

- Does the average power cost (AvgC) change when there is more demand than offer?

When the demand is larger than the offer the price increases, whereas when the offer is less than the overall demand the price decreases. Anyhow the differences are not greater than 3 units.

- What is the percentage of energy sold in the double auction market?

Most of the time 100% of the energy is sold in the primary market. Therefore, the secondary and the balancing markets are not created. Also if you observe the demand curve, you can see that *primaryDemand* gets to 0.

What is the effect of changing the demand model from working days to another model (namely holidays, Saturdays, and Sundays)?

When you set a holidays, Saturdays, and Sundays demand model the demand is lower, and thus AvgC decreases. Besides that, the producers can fulfill the demand more times and the number of blackouts drops down.

Exercise 6

- If the system operator required that the safety power of producers is less than 10%, do you reckon that there would be any blackouts?

Yes, some blackouts occur when the demand grows up quickly because producers slowly react.

- Out of the three types of markets ran so far, and taking into account that the features of producers and consumers in the three of them are the same, which one is the less risky?

From the point of view of the system operator the first type of market is better, because a blackout never occurs. Besides that, the consumers may make more profit in this market because with a lot of producers there is more market competition and the price decreases. Finally, the producers make more profits in the second market (the scarce one) because all their production is sold.

Exercise 7

The es.csic.iiia.electricitymkt.consumer.QConsumerAgent and es.csic.iiia.electricitymkt.producer.QProducerAgent classes implement this algorithm. More concretely, the algorithms implementing the performance in the double auction scene are located at:
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/producer/QDoubleAuctionPerformance.java
and
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/consumer/ QDoubleAuctionPerformance.java
respectively.

HINT: In order to solve this exercise all the student must do is to look at the contents of the ProducerAgent API.

Exercise 8

- Do you think that this type of producers adapt to the market conditions?

No, because normally the producers offer all their capacity, so the primary offer does not adapt to the primary demand. In other words the quantity offered is not intended to match the energy required. Therefore, the market does not change.

Exercise 9

The es.csic.iiia.electricitymkt.consumer.REConsumerAgent and the es.csic.iiia.electricitymkt.producer.REProducerAgent are the classes that implement this algorithm. You can find them in the following files:
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/consumer/REConsumerAgent.java

and
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/consumer/REConsumerAgent.java

respectively.

HINT: Students only have to code the *setPrimaryResult* method in REProducerAgent. In fact, they only have to code the update of propensities, namely the formulae provided in the presentation employed by producers to assess their future prices. But before that, it is worth having a look at the *initializeArrays* method.

Exercise 10

- Do you observe whether the average power cost (AvgC) stabilizes or else suffers from oscillations?

It stabilizes likewise the SLIE agents.

- Observing the behaviour of producing agents in the double auction, what can you say about their degree of aggressiveness? Do they try to continuously maximize their profits or else they adopt a conservative behaviour?

The agents are too conservative. Thus, when an agent manages to sell, he does not move from the winning price because the bidding algorithm reinforces winning prices. Agents do not try to maximize their benefits, and the distance between offer and demand prices remains stable. Moreover, failures cause that it takes a long time for agents to recover and win again. This is because while an agent wins, the winning prices are reinforced while the rest are not. When the agent fails because the market moves to other prices, it may take a long time for the agent to react. The problem is that it takes a long time for the algorithm to penalize former winning prices so that new bidding prices can be submitted.

Exercise 11

The es.csic.iiia.electricitymkt.consumer.REVConsumerAgent and the es.csic.iiia.electricitymkt.producer.REVProducerAgent are the classes that implement this algorithm. You can find them in the following files:
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/consumer/REVConsumerAgent.java

and
ElectricityMarket/src/java/es/csic/iiia/electricitymkt/consumer/REVConsumerAgent.java

respectively.

HINT: Again, students only have to code the *setPrimaryResult* method in *REVProducerAgent*.

Exercise 12

- Do you observe whether the average power cost average (AvgC) stabilizes or else suffers from oscillations?

The variation of the AvgC is more significant with this type of agents, and also the price grows and decreases as the market changes.

- What is the effect of changing the demand model from working days to another model (namely holidays, Saturdays, and Sundays)?

As intuitively expected, if the demand is greater than the offer AvgC increases. If the offer is greater than the demand the price decreases.

More importantly, notice that the overall demand is not all sold in the primary market, and thus agents must participate in the secondary and balancing markets.

- What happens in terms of AvgC in the three market configurations (scarce, balanced, overproduction)?

In any market AvgC follows the offer-demand rule mentioned above.

- What do you observe concerning AvgC if you change the risk factor of producing agents (e.g. try with 20% and 30%)?

Agents' offer prices are more varying. Thus, the distance between their offer prices is proportional to the risk they take.

- Observing the behaviour of producing agents in the double auction, what can you say about their degree of aggressiveness? Do they try to continuously maximize their profits or else they adopt a conservative behaviour?

They are aggressive because they normally do not say the same offer price twice consecutively. They try to increase their offer prices if they manage to sell all the quantity they offer (they consider that the market demand is going up). Moreover, if they do not sell all the offered energy, they decrease the next offer prices to try to sell as much energy as possible, and thus increase their market share.

Exercise 13

A possible startegy for a producer could be:

```
//Initialization
double minValue = producer.getEnergyCost();
double maxValue = 100;
```

```
double risk = 0.1;


//calculing price of the double auction
return minValue + Math.random() * ( maxValue - minValue );


//If sold energy in the double auction
maxValue = Math.max(
  maxValue
  ,priceOfTheDoubleAuction + ( risk * priceOfTheDoubleAuction )
);

//if not
maxValue = priceOfTheDoubleAuction - 1;
```