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Negotiation strategies of programmable agents in Continuous Double Auctions

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Contents

Chapter 1

Introduction

Auctions as a method of selling and buying goods have a long history, initially there were only ascending auctions with simple rules (now known as English auctions) but with time a variety of types of auctions has emerged. Now, auctions have become a very popular method of trading popularized by on-line auctions as Ebay or Allegro (a big Polish auction platform).

According to definition made by McAfee and McMillan in 1987: "an auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants".

A special type of auctions, maybe not the most popular in an on-line internet auctions but interesting from point of view of computer simulation, are so called *double auctions*. In double auctions, there are multiple buyers and sellers on the market that place their offer simultaneously.

In this work we review strategies of agents participating in a double auction. There are a lot of different categories of strategies: some consider history, others are reacting on the last placed bid or apply learning algorithms. Some strategies, as ZI, GD, and AA, have been already reviewed in an earlier publication of the present authors [21]. They are repeated here to make a possibly full compendium of strategies proposed in the literature.

The practical context of this research is the double auction for trading emissions of pollutants. Emission, in this context, is the short name for "permission to emit a unit of greenhouse gas"; its unit is either one tonne of carbon dioxide or the mass of another greenhouse gas which is recalculated to so-called carbon dioxide equivalent (tCO2e) emissions. This is expressed in units like Certified Emission Reductions (CERs) or carbon credits. This concept was introduced in the Kyoto Protocol, which entered into force in

16 February 2005, obliging countries that ratified it to limit their greenhouse gases (GHG) emissions below the levels of 1990.

The protocol introduced so called "flexible" market-based mechanisms (Emission Trading, Joint Implementation and Clean Development), which are meant to achieve the common reduction target with minimal costs, without knowledge of the parties cost functions. The emission trading market is still not mature and it is still under the process of adjusting the rules and protocols to make it efficient aud resistant to collapsing. The Chicago Climate Exchange market ceased operations in 2010 because the legislation was refused by the US Senate and companies were no longer interested in trading this commodity.

There are different schemes developed for this type of market. In report [26], the English auction trading scheme for emission permit trading was considered. In the present work the double auction mechanism for emission trading is defined, as it is a very popular method of creating efficient markets.

This work summarizes the most well known strategies, that present the evolution of automated negotiation strategies: from simple and intuitive approaches as ZI, PS and ZIP, to more forecasting like GD and adapting as AA strategy. None of the general issues of on-line auctions are discussed here. An interested reader is referred to recent reviews of these matters [12, 17, 24].

The structure of the paper is as follows. In chapter 2 the current state of research on the Continuous Double Auction, emission trading and agent strategies are shortly reviewed. In the following chapter the concept of negotiations and different ways of trading is described. In chapter 4 some informations on double auction are presented. Chapter 5 discusses the formal model of the auction double market used in this paper. The following chapters contain the description of the existing strategies for participants in the continuous double auction, they are divided to strategies using only current information, GD strategies, AA strategies and FL-strategy, that uses fuzzy rules to determine the value of next shout. The general architecture of the implemented software is located in the chapter 10, followed by description of its implementation. In chapter 11 some preliminary results are presented. Conclusions summarizes the whole report. Also future works are sketched there.

Chapter 3

Negotiations

3.1 Negotiation

A negotiation is a dialog between two or more parties, in order to resolve a conflict or to reach an agreement. A dialog is an exchange of communicates between two or more parties to reach their personal aim. The details of conducting the negotiation define most of the trading schemes. The automated agents negotiate parameters of the deal, as for example price, or conditions of delivery. Negotiations require that some elements are well defined:

- the negotiation set, which is a set of possible solutions that can be achieved,
- the protocol of negotiations, which defines the behavior of agents during the interactions,
- the strategies of the agents, which are the procedures used by the agents to achieve their objectives,
- the rules that define, when the agreement can be reached.

The negotiation models can be divided into two categories: bilateral negotiations, which involve usually two parties[1], and auctions that include multiple parties. A short description of both is provided below.

[1]There exists a notion of multilateral negotiations, but because of their complicated protocols, they are not used in the trading.

3.2 Bilateral negotiations

Bilateral negotiations involve two bargaining parties, which usually try to fix a complex contract covering e.g. such features of the traded good, as quantity, quality, price, delivery time, etc. In [12] three groups of negotiation models are considered:

Explicit reasoning about the opponent's behaviour. Negotiations in this group are mainly based on noncooperative game theory. To support elaboration of a decision, the knowledge coming from earlier bargaining is gathered, for example in a form of belief function.

Finding the current best solution. In this group an agent maximizes its own profit subject to its constraints and current negotiation situation.

Argumentation. In this kind of negotiation agents exchange additional information, explaining its moves or critique of the opponent's moves. This model seems to be less suitable for programmable agents. However, more advanced protocols and strategies may include some argumentation elements.

3.3 Auctions

Auctions are well known market mechanisms. An auction is initiated by one or more agents (called auctioneers). Other agents (called bidders) bid according to an established protocol. Among many types of auctions there are five commonly used:

(i) the English Auction, where buyers bid increasing prices,

(ii) the First-Price Sealed-Bid Auction, where bids are concealed,

(iii) the Vickerey Auction or the second bid auction, where the highest bidder wins, but pays the second price,

(iv) the Dutch Auction or Dutch Flower Auction, where sellers offer decreasing prices, and

(v) the Continuous Double Auction (CDA), where sellers offer decreasing prices and buyers bid simultaneously increasing prices.

The auctions (i) to (iv) are the single sided auctions, in which only buyers, in (i) to (iii), or sellers, in (iv), change their offers. In the double auction, like (v), the offers can be indicated from both sides. Both type of traders are free to accept orders of other side at any time.

The dominant strategies are known for the English auction and the Vickrey auction. In the former one the dominant strategy of a buyer is to bid a small amount above the current highest bid. In the latter it is to bid the buyer's true valuation of a good. For the Double auction (v) there is no dominant strategy known [23]. A more detailed characterization of auctions can be found in [12]. In the present report we confine only to the CDA auctions.

All parties that take part in the auction should follow a set of rational assumptions [4]:

- Offers should not bring losses, that is the sellers and buyers should not exceed their limit prices.
- Offers should be not crossing, which means that there should be a reason for joining the market at all. If on a free market the better price can be achieved there is no reason to continue the auction.
- Offers should reduce the ask-bid spread, which means they should be rational.

Additionally, Phelps et al. in [23] described the features of a well-designed auction market. According to the paper, an auction should allow reaching optimal solution (definition of optimal depend on the type of market and commodity), there should be an ability to make a deal without inward or outward transfers of good and funds, the auction schema should promote rational behaviours, and participants should not be able to gain an advantage from non-truthtelling behaviour (objective called strategy-proofness).

In [8] the terminology that distinguished the Clearing-House from the Continuous Double Auction was introduced. The Clearing-House is a type of a Double Auction in which bids and offers are gathered for some time until the market clearing occurs. Market clearing is a process of computing the price at which the supply and demand on the market are equal, this price is called the equilibrium price. The aim of that procedure is to maximize the overall surplus on the market. It is especially beneficial if the participants are placing offers with their true valuation of the commodity.

On the other hand, in the Continuous Double Auction the broker is looking for matching offer immediately after each bid or ask is placed. This is

an incentive to announce non-truthful bidding which allows to make bigger profits.

Chapter 12

Conclusions

Emission permits are a new commodity that can have a very uncertain volume. Moreover, uncertainties for different types of greenhouse gases differ considerably. For example, uncertainty of emission of CO_2 from a power plant may be few percents, while that of N_2O from agricultural activities may be close to 100%. Thus, a risk for traders to realy reach the imposed emission level is much different when buing one or another emissions. Trading under such conditions requires new rules, but also provides a unique base to develop new strategies that are able to fulfill the requirements. Before it will be possible to include uncertainties in the agents behavior, the market scheme has to be designed and tested.

Given the tool as the *multi-agent system*, it is possible to design a market that is be simple, dynamic and that allows participants to adjust their desired profit and the time of placing an offer. The continuous double auction chosen in the report has simple rules and does not impose limitations on neither the number of participants nor their strategies.

The aim of the present report is to go through the most well-known strategies for this type of market, to classify them and to summarize their properties. The existing strategies can be divided into few groups: simple and reactive strategies (e.g. TT, ZI, ZIP); strategies that are using historical data to predict the prices (e.g. GD) and strategies that are exploiting features of agents and market configuration (e.g. Kaplan, AA). Most of the strategies (except for the very simple ones) result in the market price converging to equilibrium price and generally in most participants reaching profit.

The next step is to create agents that will dynamically adjust or even change their strategies depending on the situation on the market. After

that, specific features of the emission market will be added to check how agents behave. Limit price will become a function of traded permits and participants would have to consider the level of uncertainty of the traded permit.

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